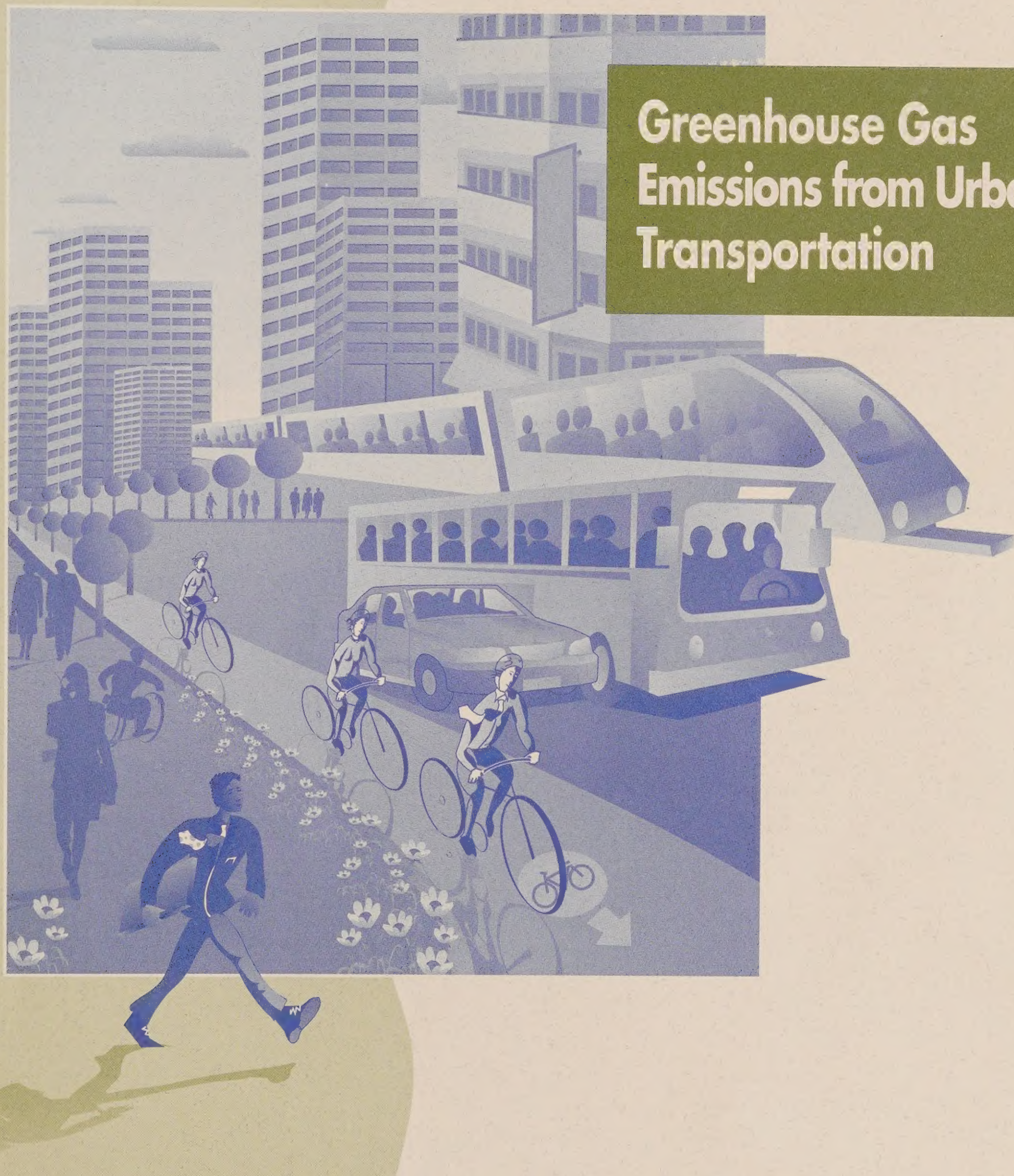
Backgrounder



Greenhouse Gas Emissions from Urban Transportation

National Round Table on the Environment and the Economy

Table ronde nationale sur l'environnement et l'économie

Canadian Cataloguing in Publication Data

Main entry under title:

Greenhouse gas emissions from urban transportation: backgrounder

Issued also in French under title: Les émissions de gaz à effet de serre provenant des transports urbains.

ISBN 1-895643-76-7

1. Greenhouse gases — Environmental aspects — Canada. 2. Carbon dioxide — Environmental aspects — Canada. 3. Urban transportation — Environmental aspects — Canada. 4. Greenhouse gases — Government policy — Canada. 5. Urban transportation policy — Canada. I. National Round Table on the Environment and the Economy (Canada).

TD885.5.G73G73 1998 363.738'74'0971 C98-901410-X

This book is printed on Environmental Choice paper containing over 50 percent recycled content including 10 percent post-consumer fibre, using vegetable inks. The coverboard also has recycled content and is finished with a water-based, wax-free varnish.

National Round Table on the Environment and the Economy
344 Slater Street, Suite 200
Ottawa, Ontario
Canada K1R 7Y3
Tel.: (613) 992-7189
Fax: (613) 992-7385
E-mail: admin@nrtee-trnee.ca
Web: http://www.nrtee-trnee.ca

Other publications available from the National Round Table Backgrounder series:

1. Sustainable Transportation in Canada
2. Going for Green: Meeting Foreign Demand for Environmentally Preferable Products and Services through Federal Procurement
3. Contaminated Site Issues in Canada
4. Improving Site-Specific Data on the Environmental Condition of Land
5. Removing Barriers: Redeveloping Contaminated Sites for Housing
6. The Financial Services Sector and Brownfield Redevelopment
7. Measuring Eco-efficiency in Business

Toutes publications de la Table ronde nationale sur l'environnement et l'économie sont disponibles en français.

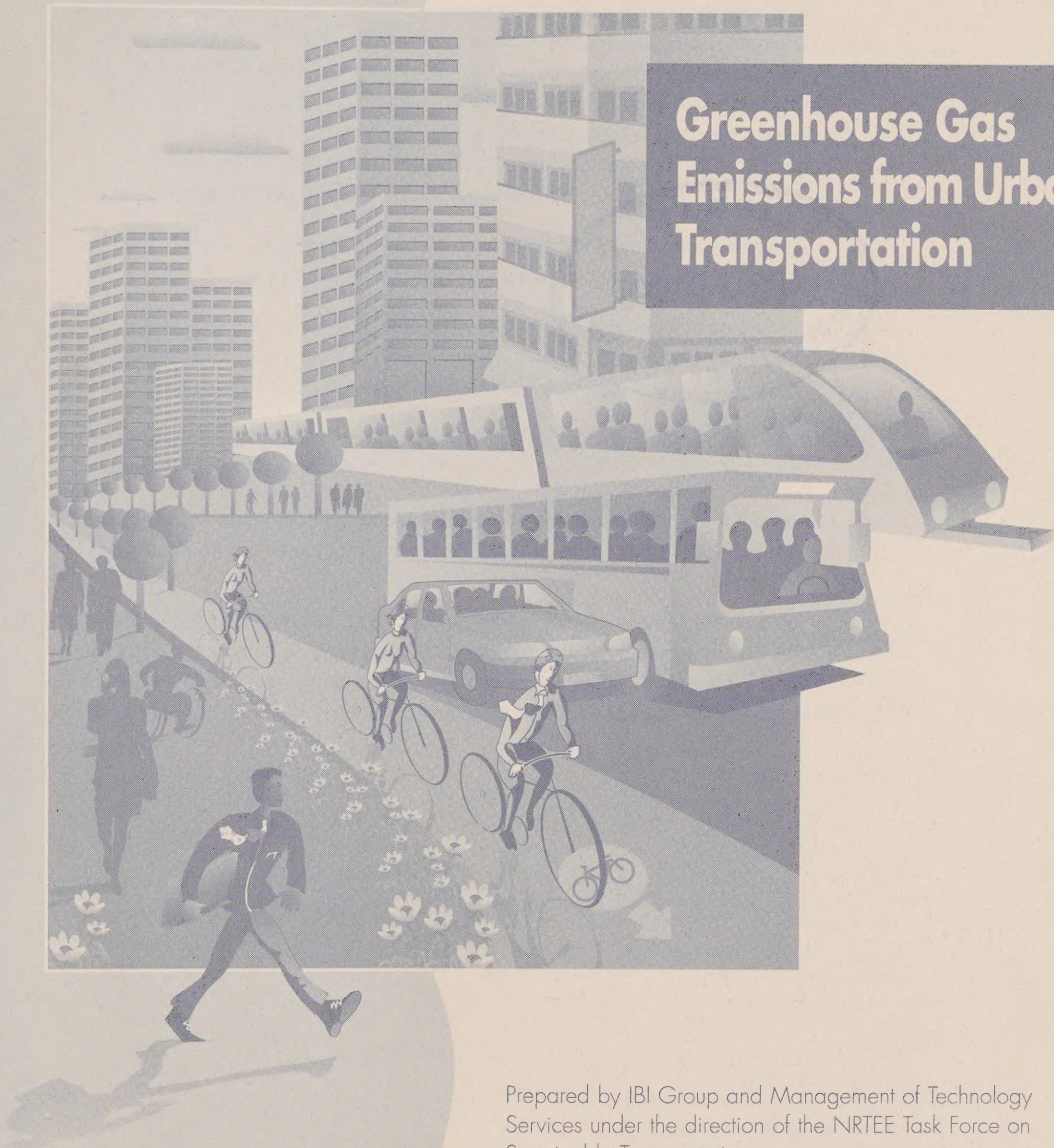
To order:

Renouf Publishing Co. Ltd.
5369 Canotek Road, Unit #1
Ottawa, ON K1J 9J3
Tel.: (613) 745-2665
Fax: (613) 745-7660
Internet: http://www.renoufbooks.com
E-mail: order.dept@renoufbooks.com

Price: C$14.95 plus postage and tax

Backgrounder

Greenhouse Gas Emissions from Urban Transportation



Prepared by IBI Group and Management of Technology Services under the direction of the NRTEE Task Force on Sustainable Transportation.

The views expressed herein are those of the authors and editors, and do not necessarily represent those of the National Round Table or its members.

Mandate

The National Round Table on the Environment and the Economy (NRTEE) was created to "play the role of catalyst in identifying, explaining and promoting, in all sectors of Canadian society and in all regions of Canada, principles and practices of sustainable development." Specifically, the agency identifies issues that have both environmental and economic implications, explores these implications, and attempts to identify actions that will balance economic prosperity with environmental preservation.

At the heart of the NRTEE's work is a commitment to improve the quality of economic and environmental policy development by providing decision makers with the information they need to make reasoned choices on a sustainable future for Canada. The agency seeks to carry out its mandate by:

- advising decision makers and opinion leaders on the best way to integrate environmental and economic considerations into decision making;
- actively seeking input from stakeholders with a vested interest in any particular issue and providing a neutral meeting ground where they can work to resolve issues and overcome barriers to sustainable development;
- analyzing environmental and economic facts to identify changes that will enhance sustainability in Canada; and
- using the products of research, analysis and national consultation to come to a conclusion on the state of the debate on the environment and the economy.

The NRTEE's state of the debate reports synthesize the results of stakeholder consultations on potential opportunities for sustainable development. They summarize the extent of consensus and reasons for disagreement, review the consequences of action or inaction, and recommend steps specific stakeholders can take to promote sustainability.

Members of the National Round Table on the Environment and the Economy

The NRTEE is composed of a Chair and up to 24 distinguished Canadians. These individuals are appointed by the Prime Minister as opinion leaders representing a variety of regions and sectors of Canadian society including business, labour, academe, environmental organizations, and First Nations. Members of the NRTEE meet as a round table four times a year to review and discuss the ongoing work of the agency, set priorities, and initiate new activities.

Chair
Dr. Stuart Smith
Chairman
ENSYN Technologies Inc.
Etobicoke, Ontario

Vice-Chair
Lise Lachapelle
President & CEO
Canadian Pulp & Paper Association
Montreal, Quebec

Vice-Chair
Elizabeth May
Executive Director
Sierra Club of Canada
Ottawa, Ontario

Paul G. Antle
President & CEO
SCC Environmental Group Inc.
St. John's, Newfoundland

Jean Bélanger
Ottawa, Ontario

Allan D. Bruce
Administrator
Operating Engineers' (Local 115) Joint
Apprenticeship & Training Plan
Burnaby, British Columbia

Patrick Carson
Strategic Planning Advisor
Loblaw - Weston Companies
Toronto, Ontario

Elizabeth Jane Crocker
Co-Owner, P'lovers
Halifax, Nova Scotia

Douglas B. Deacon
Owner
Trailside Café and Adventures
Charlottetown, Prince Edward Island

Johanne Gélinas
Commissioner
Bureau d'audiences publiques sur l'environnement
Montreal, Quebec

Sam Hamad
Vice-President, Industry
Roche Ltd., Consulting Group
Sainte-Foy, Quebec

Dr. Arthur J. Hanson
Distinguished Fellow & Senior Scientist
International Institute for Sustainable Development
Winnipeg, Manitoba

Michael Harcourt
Senior Associate
Sustainable Development
Sustainable Development Research Institute
Vancouver, British Columbia

Cindy Kenny-Gilday
Yellowknife, NWT

Emery P. LeBlanc
Executive Vice-President
Alumina and Primary Metal
Alcan Aluminium Limited
Montreal, Quebec

Anne Letellier de St-Just
Lawyer
Quebec, Quebec

Ken Ogilvie
Executive Director
Pollution Probe Foundation
Toronto, Ontario

Joseph O'Neill
Vice-President
Woodlands Division
Repap New Brunswick Inc.
Newcastle, New Brunswick

Angus Ross
President
SOREMA Management Inc. &
CEO, SOREMA Canadian Branch
Toronto, Ontario

Irene So
Vice-President and Associate Portfolio Manager
RBC Dominion Securities
Toronto, Ontario

John Wiebe
President & CEO
GLOBE Foundation of Canada
and Executive Vice-President
Asia Pacific Foundation of Canada
Vancouver, British Columbia

Executive Director & CEO
David J. McGuinty

Table of Contents

List of Exhibits

Preface

Urban transportation has an undeniable impact on the emission of greenhouse gases as well as various other pollutants. Over one-quarter of Canada's greenhouse gas emissions comes from the transportation sector, and approximately half comes from urban transportation. In Canada's 13 largest Census Metropolitan Areas (CMAs), over three-quarters of the greenhouse gas emissions produced by urban transportation are due to personal transportation, and 97% of these emissions are attributed to private automobiles and light trucks in personal use. These figures suggest that passenger transportation and the private automobile should be the highest priority in actions to reduce CO_2 emissions from urban transportation.

However, urban transportation policies that lead to greenhouse gas reductions are also being considered for other, more immediate reasons such as the human health impacts of smog. Both economic considerations and increasing concern about air quality have helped to produce transportation plans and policies in several Canadian urban areas that attempt to reduce automobile use through measures such as carpooling, land use planning, parking management and public education.

What will be the greenhouse gas reduction impact of these planned activities, and of other urban transportation policies? This question has taken on an increased importance due to the negotiation of the Kyoto Protocol where Canada has committed to reduce national greenhouse gas emissions by 6% of 1990 levels to be achieved between the years 2008 and 2012. This backgrounder is one of the first examinations of how urban transportation policies can contribute to Canada's commitment. More importantly, it also investigates the synergistic benefits that stem from simultaneously implementing several complementary policy measures.

Greenhouse Gas Emissions from Urban Transportation represents the second phase of the NRTEE's sustainable transportation program. In November 1997, the NRTEE concluded the first phase by publishing the *State of the Debate on the Environment and the Economy: The Road to Sustainable Transportation in Canada.* This report, based on extensive research and consultation with a wide range of stakeholders, described areas of stakeholder consensus and disagreement, and offered recommendations on how to advance sustainable transportation in Canada.

IBI Group and Management of Technology Services, under the direction of the NRTEE Task Force on Sustainable Transportation, prepared this backgrounder. The authors accept full responsibility for their interpretation of the issues. While it is the result of substantial research and consultation, the content of this report does not necessarily represent the views of the NRTEE. However, recognizing the need for research and discussion on this issue, the NRTEE hopes that this document will contribute to the general debate that society must undertake in order to deal with the global issue of climate change.

J. Gélinas

Johanne Gélinas
Chair, Task Force on Sustainable Transportation
National Round Table on the Environment and the Economy

National Round Table on the Environment and the Economy (NRTEE) Task Force on Sustainable Transportation

Chair
Johanne Gélinas
Commissioner
Bureau d'audiences publiques sur l'environnement (BAPE)
NRTEE Member

Al Cormier
Chair
Centre for Sustainable Transportation

John Hartman
Director, Transportation Forum
Transportation Association of Canada

Phil Kurys
Director, Sustainable Development
Transport Canada

Ken Ogilvie
Executive Director
Pollution Probe Foundation
NRTEE Member

Frank Vena
Director, Transportation Systems Branch
Environment Canada

NRTEE Staff:
Carolyn Cahill
Policy Advisor

Executive Summary

Introduction

Responding to growing concerns regarding climate change resulting from greenhouse gas (GHG) emissions, the National Round Table on the Environment and the Economy (NRTEE) has established a program to:

- maintain and build momentum on the transportation GHG issue generated by earlier NRTEE reports and the Kyoto Protocol;
- initiate a national debate on the critical issue of GHG reduction in the urban transportation sector; and
- identify possible options for a Canadian strategy, which would then be developed by others.

The goal of this report is to estimate the GHG reduction contribution that can be expected from various urban sustainable transportation policies.

This Backgrounder Report is one of the first examinations of how urban transportation policies can contribute to Canada's commitment to the Kyoto Protocol. However, it does not represent the views of the NRTEE. Rather, it is a contribution to the general debate on reducing GHG emissions from the transportation sector and to the National Implementation Process of the Kyoto Protocol.

The Climate Change Challenge

There is increasing evidence that rising concentrations of GHGs — the most important of which is carbon dioxide (CO_2) — have contributed to an increase of approximately 0.5°C in global average temperature over the past century. Moreover, continued warming can be expected if the increase in atmospheric concentrations of GHGs — much of which is due to the burning of fossil fuels and other human activities such as deforestation and industrial processes — is allowed to continue unabated. Climate modelling studies and climate trends during the past few decades indicate that global warming is increasing the frequency and intensity of extreme weather events, droughts and desertification in currently inhabited areas. If warming continues over the next 50 to 100 years and beyond, sea levels will rise, leading to flooding in coastal and other low lying areas.

Various international meetings have taken place aimed at limiting emissions of GHGs and other harmful substances. The most recent of these resulted in the Kyoto Protocol of December 1997, under which Canada agreed to reduce its GHG emissions to 6% below 1990 levels in the 2008 to 2012 period. While Canada has not yet ratified the Kyoto Protocol, there is an implied national commitment. Since the Kyoto Conference, Canadian ministers of energy and environment have

approved a process to examine the impacts, costs and benefits of implementing the Kyoto Protocol, as well as Canada's options for implementing the Protocol. This process will lead to the development of a national implementation strategy on climate change. The NRTEE and other government and non-government agencies are part of this process and are working to identify and help implement initiatives to achieve the Kyoto target.

Role of Urban Transportation in the Production of Greenhouse Gases

As summarized in Exhibit 2.5 in the body of the report, in 1995 total Canadian GHG emissions were some 619 million tonnes (MT) of CO_2 equivalent.[1] Of this, 26% (163.5 MT) is attributed to transportation. And of that amount, approximately 50% (82 MT) is attributed to urban transportation overall and about 37% (60 MT) to urban transportation in the country's 13 largest Census Metropolitan Areas (CMAs). About 78% of the GHG emissions from urban transportation come from passenger transportation and about 22% from freight transportation. In Canada's 13 largest CMAs, urban transportation produces about 9.7% of total Canadian GHG emissions.

Approximately 7.4% of Canada's total GHG emissions are due to personal transportation in Canada's 13 largest CMAs, of which 97% is attributed to private automobiles and light trucks in personal use. These figures suggest that passenger transportation and the private automobile should be the highest priority in actions to reduce CO_2 emissions from urban transportation. However, urban trucking also deserves attention, but presents greater challenges because of the difficulty of reducing freight volumes, substituting other modes or introducing vehicles that produce lower emissions.

---

[1] CO_2 accounts for approximately 81% of GHGs emitted by Canadian sources. The other portion is made up largely of methane and nitrous oxide. The CO_2 equivalent is 21 tonnes of CO_2 for 1 tonne of methane and 310 tonnes of CO_2 for 1 tonne of nitrous oxide. Source: Government of Canada, *Canada's Second National Report on Climate Change: Actions to Meet Commitments Under the United Nations Framework Convention on Climate Change*, May 1997.

Assessment of Options to Reduce CO_2 Emissions

This study examined 11 types of initiatives (referred to as options) that can be taken to reduce CO_2 emissions from urban transportation. Chapter 3 presents information from the literature on the elasticities of demand associated with most of the options. It provides estimates of the CO_2 reductions likely by 2010 if each option were to be introduced singly during the next few years in the 13 CMAs studied. It also comments on the momentum provided by these initiatives for significant additional reductions beyond 2010. Some of these initiatives are intended to reduce GHG emissions by changing behaviour (i.e., by reducing the number of kilometres driven), while others are intended to increase fuel efficiency by stimulating the development and implementation of improved technology. Others, such as increased fuel taxes, can be expected to change behaviour and improve technology.

The results of the study's analyses are summarized in Exhibit 1 (Exhibit 3.14 in Chapter 3). The exhibit presents results for 7 of the 11 options, for which demand elasticity information is felt to be sufficiently reliable as a basis for estimating CO_2 reductions.

As shown in the exhibit, no single measure has the potential to (1) achieve the Kyoto target or (2) offset the predicted 22% increase in CO_2 emissions from urban transportation by 2010 relative to 1990 — an increase predicted using a business-as-usual scenario. Increased gasoline taxes are estimated to have the greatest potential for reductions. If applied throughout North America, an increase of 3 cents per litre in the gasoline tax each year starting in 2000 is estimated to lead to CO_2 emissions levels about 14% lower than the 2010 business-as-usual prediction. If the same gasoline tax increase were applied in Canada only, CO_2 levels would be 9% lower than the 2010 business-as-usual prediction. Canada-only taxes would have less impact than North America-wide taxes because there would not be the same degree of investment in and development of fuel-saving technologies. Each of the other initiatives shown in Exhibit 1, if applied individually, would also reduce CO_2 emissions by 2010 relative to the business-as-usual level. These reductions are estimated to be in the range of 1% to 11%.

Exhibit 1

Summary of Estimated CO_2 Emissions Reduction Impacts of Policy Options (top 13 CMAs in Canada)

	Passenger	Freight	Total
Baseline Emissions (1990)	39,589	8,390	47,979
Business-as-Usual Emissions (2010)	45,581	12,887	58,468
% Change from 1990	15%	54%	22%
Policy	**Reduction in 2010 (MT)**	**% Change from 2010 Business-as-Usual**	**% Change from 1990 Level**
Gasoline Tax[a]			
Scenario 1A: Gasoline tax ($0.03/litre annually, Canada only)	-5.3	-9%	11%
Scenario 2A: Gasoline tax ($0.054/litre annually, Canada only)[b]	-9.4	-16%	2%
Scenario 1B: Gasoline tax ($0.03/litre annually, North America-wide)	-8.0	-14%	5%
Scenario 2B: Gasoline tax ($0.036/litre annually, North America-wide)[b]	-9.5	-16%	2%
Diesel Tax			
Diesel tax ($0.03/litre annually, North America-wide)	-1.0	-2%	20%
CAFE and CAFC			
Canada only: 1% annual improvement taking effect in 2005 (new vehicles only)	-0.7	-1.2%	20%
North America-wide: 2% annual improvement taking effect in 2005 (new vehicles only)	-1.2	-2.1%	19%
Feebates[a]			
Feebates implemented in Canada only			
C$350/litre/100 km	-0.7	-1%	20%
C$700/litre/100 km	-1.1	-2%	20%
C$1,400/litre/100 km	-2.2	-4%	17%
C$2,800/litre/100 km	-4.0	-7%	14%
Feebates implemented North America-wide			
C$350/litre/100 km	-2.2	-4%	17%
C$700/litre/100 km	-3.1	-5%	15%
C$1,400/litre/100 km	-4.4	-8%	13%
C$2,800/litre/100 km	-6.2	-11%	9%
Vehicle Maintenance and Inspection Programs			
Impacts assuming 1% reduction in fleet emissions	-0.6	-1%	21%
Impacts assuming 3% reduction in fleet emissions	-1.8	-3%	18%
Parking Pricing			
Impacts of 5% annual parking price increase	-4.6	-8%	12%
Road Pricing			
$0.10 peak/$0.05 off-peak	-1.5	-2%	19%
$0.20 peak/$0.10 off-peak	-2.9	-5%	16%

Notes:

CAFE/CAFC = Corporate Average Fuel Efficiency/Consumption

[a] Estimated emission reductions from distance-based insurance and vehicle registration fees are assumed to be similar to those of gasoline taxes and feebates respectively.

[b] These are the price increases that would be required to achieve a 6% reduction in CO_2 emissions from 1990 levels by 2010 for gasoline vehicles only.

Development and Assessment of Integrated Packages of Options

Advantages of Integrated Packages

Various studies have demonstrated that integrated packages of options will be substantially more effective in reducing CO_2 emissions than any single initiative. This is because of mutually reinforcing interactions among the various types of initiatives. For example, if user prices are increased for car drivers in urban areas, the reduction in vehicle-kilometres travelled (vkt) by automobiles will be significantly greater if, at the same time, significantly improved public transit is provided.

Exhibit 1

Summary of Integrated Packages

Individual Initiatives	Combinations					
	Package A		Package B		Package C	
	Road Vehicles — Basic		Road Vehicles — Alternative		Comprehensive Package	
	Canada only	North America-wide	Canada only	North America-wide	Canada only	North America-wide
1 Fuel taxes (gasoline)	✔	✔			✔	✔
Fuel taxes (diesel)		✔				✔
2 CAFE/CAFC	✔	✔			✔	✔
3 Feebates	✔	✔			✔	✔
4 Vehicle I&M			✔	✔	✔	✔
5 Vehicle charges and taxes			✔	✔		
6 Parking pricing/supply			✔	✔	✔	✔
7 Road pricing			✔	✔	✔	✔
8 Alternative fuels			✔	✔		
9 TDM					✔	✔
10 Enhanced transit					✔	✔
11 Land use/urban design					✔	✔

Notes:

CAFE/CAFC = Corporate Average Fuel Efficiency/Consumption
I&M = inspection and maintenance
TDM = transportation demand management

Another example relates to a regulatory option known as Corporate Average Fuel Efficiency/Consumption (CAFE/CAFC) measures, which are similar to earlier regulations of this type applied in the United States and Canada. This study defines the CAFE/CAFC option as a regulated CO_2 reduction for new vehicles of 2% per year, starting in 2005, applied North America-wide or in Canada alone, as shown in Exhibit 1. If this type of regulation were introduced, its impact would be reduced over time by what is known as the "take-back" effect. Under the take-back effect, drivers would tend to travel further to take advantage of lower spending on fuel (their vehicles would be more fuel efficient as required by the CAFE/CAFC regulations). The take-back effect could be reduced or eliminated if higher fuel taxes were introduced at the same time as the CAFE/CAFC regulations, so that the fuel cost per vehicle-kilometre travelled (vkt) remained stable or even increased.

Other synergistic effects are also important. For example, transportation demand management measures (to encourage travel in off-peak periods, increase vehicle occupancy and promote the use of environmentally benign modes) could be implemented in combination with enhanced public transit services and transit-supportive, compact, mixed use urban development. These supporting packages could be expected to enhance the CO_2 reduction impacts of each other and of the other options shown in Exhibit 1.

Bearing in mind these synergistic interactions, three integrated packages of combined initiatives were identified for further analysis. (See Exhibit 2, which is also Exhibit 4.1 in Chapter 4.)

GHG Emissions Reductions

As shown, **Package A: Road Vehicles — Basic** consists of three options (increased fuel taxes, CAFE/CAFC regulations and feebates). The impacts are analyzed for Canada-only or North America-wide application. Increased taxes on diesel fuels are not included in the Canada-only package, because of concerns regarding the competitiveness of Canada's trucking industry if the tax were applied only in this country.

Package B: Road Vehicles — Alternative includes five options (vehicle inspection and maintenance, vehicle charges and taxes based on distance travelled or fuel consumption, parking pricing and supply, road pricing, and alternative fuels). The impacts of Package B are also assessed for Canada-only or North America-wide application.

Finally, **Package C: Comprehensive Package** includes the options in Package A and Package B (with the exception of alternative fuels and vehicle charges and taxes) plus three supporting measures (transportation demand management, enhanced transit, and land use/urban design).

As summarized in Exhibit 3 (derived from Exhibits 4.2, 4.3 and 4.4 of Chapter 4), all three combined packages would meet the Kyoto target by 2010 if implemented North America-wide.

Package C, the Comprehensive Package, would meet the Kyoto target whether implemented in Canada alone or North America-wide. This package would also achieve the greatest reductions in CO_2 emissions relative to 1990 levels: by 11% if applied in Canada only and by 20% if applied North America-wide.

The only packages that did not achieve the Kyoto target are packages A and B when applied in Canada alone. In this scenario, Package A would result in an estimated 5% **increase** in CO_2 emissions from urban transportation over 1990 levels, while Package B would reduce emissions relative to 1990 levels but fall just short of the 6% target.

Exhibit 3

Summary of Estimated CO_2 Emissions Reduction Impacts of Integrated Packages *(top 13 CMAs in Canada)*

	Passenger	Freight	Total
Baseline Emissions (1990)	39,589	8,390	47,979
Business-as-Usual Emissions (2010)	45,581	12,887	58,468
% Change from 1990	15%	54%	22%
Package	**CO_2 Emissions Reduction in 2010 (MT)**	**% Change from 2010 Business-as-Usual**	**% Change from 1990 Level**
Package A: Road Vehicles — Basic			
Canada only	-8.0	-14%	5%
North America-wide	-13.9	-24%	-7%
Package B: Road Vehicles — Alternative			
Canada only	-12.8	-22%	-5%
North America-wide	-15.5	-27%	-11%
Package C: Comprehensive Package			
Canada only	-15.8	-27%	-11%
North America-wide	-20.1	-34%	-20%

Economic Efficiency Impacts

Based on the evidence from various studies — primarily in Canada, the United States and Europe — Canada's economic efficiency is unlikely to be reduced by any of the combined packages, although economic growth might be slower during a transition period. It should be noted that the conclusions presented in this report are broad and qualitative, and that there is considerable uncertainty in the literature on the economic impacts of initiatives to reduce CO_2 emissions.

Assessment of Integrated Packages

Exhibit 4 (Exhibit 4.5 in Chapter 4) summarizes the assessment of the integrated options, showing the extent to which Package A, Package B and Package C (if applied in Canada alone or North America-wide) would meet the following five objectives (labelled evaluation criteria in the exhibit):

- GHG reduction: to meet or exceed the Kyoto target reductions;
- public sector cost: to be implemented without significantly increased net costs to the public sector;

- economic impacts: to be implemented without reducing Canada's economic efficiency;
- ease of early implementation: to be implemented such that impacts are realized by 2010; and
- social impacts: to be implemented while improving social equity.

As indicated in the exhibit, the overall assessment is that Package C would best meet the above five objectives, followed by Package A and Package B. If the primary objective, GHG reduction, is given more weight, then Package B would be superior to Package A.

Exhibit A

Assessment of Integrated Packages

		Package A Road Vehicles — Basic		Package B Road Vehicles — Alternative		Package C Comprehensive Package	
		Canada only	North America-wide	Canada only	North America-wide	Canada only	North America-wide
GHG Impacts: Summary							
Reduction from 2010 baseline		-14%	-24%	-22%	-27%	-27%	-34%
Reduction from 1990 baseline		+5%	-7%	-5%	-11%	-11%	-20%
Evaluation Criteria	**Objective**						
Greenhouse gas reduction	To meet or exceed Kyoto target reductions	Low	Medium	Medium	High	High	High
Public sector cost	To be implemented without significantly increased net costs to the public sector	High	High	Medium	Medium	Low	Low
Economic impacts	To be implemented without reducing Canada's economic efficiency	Low	Medium	Low	Medium	Medium	High
Ease of early implementation	To be implemented such that impacts are realized by 2010	High	Medium	High	Medium	Medium	Low
Social impacts	To be implemented while improving social equity	Medium	Medium	Low	Low	High	High
Overall Assessment		Medium	High	Low	Medium	High	High

Extent to which objectives are satisfied: Low Medium High

Conclusions

The findings of this study lead to the following conclusions:

- Policy options to reduce GHG emissions from urban transportation that involve a single initiative only are unlikely to achieve the Kyoto target (see Exhibit 1).
- Combinations of the individual initiatives show more promise, and three such combination packages were developed for analysis (see Exhibit 2).
- Any one of the three combination packages, with the exception of Package A and Package B if applied in Canada only, is estimated to meet the Kyoto target. Package C, the Comprehensive Package, is likely to achieve the greatest reductions (see Exhibit 3). Any of the packages would also build momentum for substantial CO_2 reduction trends beyond 2010, with Package C again being the most effective option.
- When other objectives — such as reasonable public sector costs, economic efficiency, ease of early implementation and reasonable social impacts — are taken into account as well as GHG reduction, Package C achieves the highest rating. Package A is slightly better than Package B when all criteria are taken into account, but Package A achieves a smaller reduction in CO_2 than Package B (see Exhibit 4).
- Based on the above, it appears feasible for Canada acting alone to achieve its Kyoto target for GHG reductions for urban transportation in the country's 13 largest CMAs. These CMAs account for almost 75% of GHG emissions from urban transportation and 10% of all GHG emissions in Canada. This conclusion is significantly strengthened if any one of the three combined packages could be implemented North America-wide, and the likelihood of success is also increased if more initiatives are added to the package.

The complexity and challenges of achieving the cooperation required for combined approaches increase as the field of action moves from Package A to Package B and onward to Package C. But the rewards from meeting these challenges — meeting and exceeding the Kyoto target while achieving other objectives (e.g., financial, economic, social) — make the effort worthwhile. Similarly, the benefits of achieving a harmonized approach across North America warrant the additional effort of attempting to achieve a cooperative approach by the national governments of Canada, the United States and Mexico. It is fortunate that, based on the findings of this study, there is excellent promise that the Kyoto target for GHG emissions from urban transportation can be reached in Canada through largely federal initiatives. There is thus good reason to act on these initiatives as soon as possible, while initiating discussions with other jurisdictions in hopes of achieving broadened, cooperative approaches.

Introduction

The overwhelming body of opinion in the scientific and environmental communities is that climate change resulting from the emission of greenhouse gases (GHGs) due to human activity poses a serious threat. There is also a growing international consensus that action will have to be taken. The Kyoto Protocol resulted in GHG reduction targets being adopted by a number of countries, including Canada. To date, however, this growing interest in taking action has not been matched by agreement on what actions should be taken and how they should be implemented.

Transportation is a significant source of GHGs and is directly responsible for 26% of Canada's total emissions; urban transportation in particular is responsible for over 50% of all transportation emissions. It is critically important to plan and initiate coordinated action to reduce GHG emissions so that Canada can meet its current international obligations and perhaps more extensive future obligations.

The NRTEE Program on Sustainable Transportation

In 1996, the National Round Table on the Environment and the Economy (NRTEE) convened a series of national workshops focusing on the issues and the barriers associated with making the Canadian transportation sector more sustainable. Over the course of these workshops, stakeholders from all parts of the transportation sector — energy producers, carriers, shippers, transportation system users, suppliers and government representatives — discussed areas of consensus and of disagreement. The results are reflected in the NRTEE's 1997 *State of the Debate on the Environment and the Economy: The Road to Sustainable Transportation in Canada*, which also offers recommendations on how to advance sustainable transportation principles in Canada.

Purpose of This Report

The challenges presented by some of the conclusions in the 1997 report led the NRTEE to explore the GHG reduction potential of various sustainable transportation policies in Canada's main urban areas. The objectives of the present Backgrounder Report, therefore, are to:

- maintain and build momentum on action on the transportation GHG issue, which was generated by the Kyoto Protocol, the NRTEE's 1997 *State of the Debate on the Environment and the Economy: The Road to Sustainable Transportation in Canada*, and other initiatives; and
- determine the GHG reduction contribution that can be expected from various urban sustainable transportation policies.

This Backgrounder Report is one of the first examinations of how urban transportation policies can contribute to Canada's commitment to the Kyoto Protocol. However, it does not represent the views of the NRTEE. Rather, it is a contribution to the general debate on reducing GHG emissions from the transportation sector and to the National Implementation Process of the Kyoto Protocol.

Structure of Report

The following chapters of this report are focused as follows:

- Chapter 1 describes the climate change problem.
- Chapter 2 describes the role of urban transportation in the production of GHGs.
- Chapter 3 outlines options to reduce GHG emissions from urban transportation and estimates their impacts.
- Chapter 4 outlines the development of three integrated packages of options and provides an assessment of the options, both in terms of carbon dioxide reduction potential and in terms of their broad economic and social implications. This chapter also provides an overall assessment of the integrated packages.
- Chapter 5 summarizes the conclusions reached.

1

The Climate Change Challenge

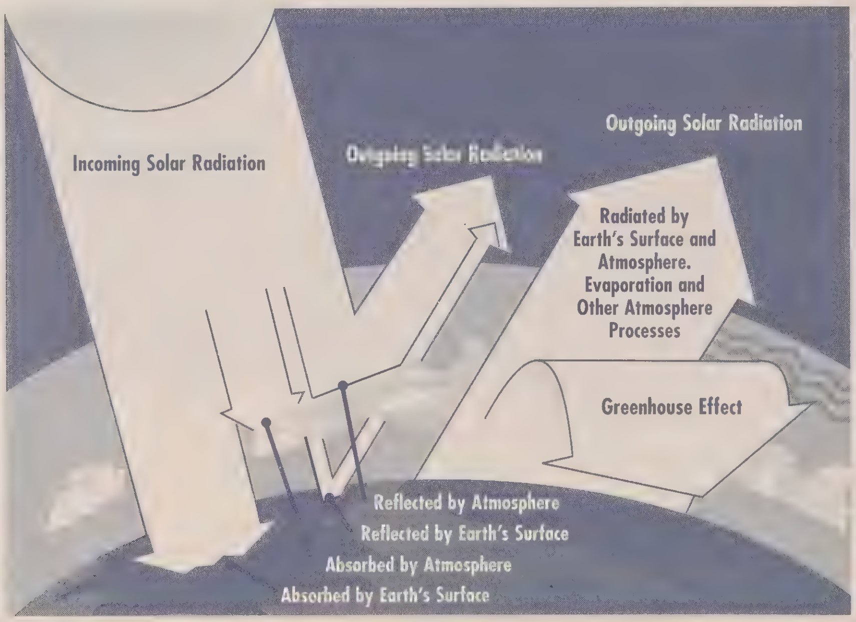
The Solar Heat Balance

Life on earth is based upon energy received from the sun. Solar energy warms the earth and provides the basic energy source for life by powering the photosynthesis process in plants. Solar energy also drives the hydrological cycle by causing water to evaporate; water vapour in the resulting clouds eventually condenses and falls back to earth as rain or some other form of precipitation. Without this continuously renewed fresh water, widespread terrestrial life as we know it would be impossible.

The stability of these processes is based upon a balance, as illustrated in Exhibit 1.1. Approximately 30% of the solar energy that reaches the earth is scattered back into space by clouds, land and water. The remaining 70% reaches the lower atmosphere and the surface of the earth. Ultimately, this energy is converted into heat. This heat radiates upward in the form of infrared radiation and would be lost into space except for the presence of greenhouse gases (GHGs) in the atmosphere. These GHGs retain some of the radiating energy, keeping the heat in the lower atmosphere and on the surface of the earth. GHGs include water vapour, carbon dioxide, methane, nitrous oxide and ozone — all naturally occurring substances.

Exhibit 1.1

The Earth's Energy Balance



Source: Environment Canada, *A Primer on Climate Change*, Draft Report (Ottawa, 1997), Fig. 8.

Impacts of Human Activity

In the last two centuries the level of human activity has reached a point where human-caused (anthropogenic) emissions are contributing significantly to the levels of GHGs in the atmosphere. Exhibit 1.2 shows the sources of both natural and anthropogenic gases.

Exhibit 1.2

Some Sources of Natural and Anthropogenic GHGs

Greenhouse Gas	Natural Sources	Anthropogenic Sources
Water vapour	Evaporation, respiration and transpiration	(Negligible)
Carbon dioxide	Decaying plants, animal respiration, natural burning, volcanoes	Burning fossil fuels (oil, coal, natural gas), deforestation, industrial processes
Methane	Decaying plants, animal digestion, volcanoes	Landfill, oil and gas production, domestic livestock
Nitrous oxide	Released from soils and oceans	Burning fossil fuels, chemical production, nitrogen fertilizers
Halocarbons	(None)	Wide variety of industrial and consumer products

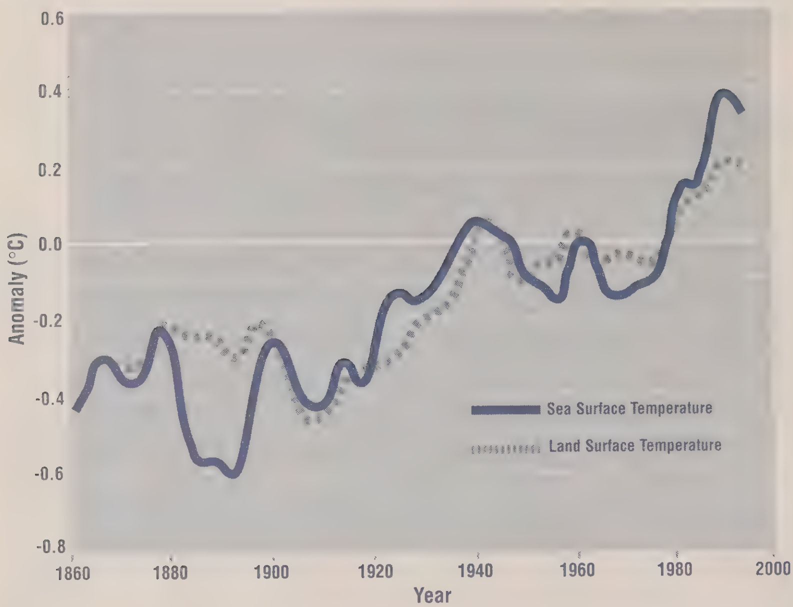
Source: Transportation Association of Canada, *A Primer on Urban Transportation and Global Climate Change* (Ottawa, May 1998).

The most important of the anthropogenic sources is carbon dioxide (CO_2), which accounts for 81% of the impact of the anthropogenic GHG emissions. "Over the past 200 years, atmospheric concentrations of carbon dioxide have increased by 30%, methane by 145% and nitrous oxide by 15%. Continued increases are predicted both worldwide and in Canada."[1]

At the same time, as illustrated in Exhibit 1.3, the global average temperature has increased by 0.5°C over the past century, with much of that change occurring in the past 40 years. Average temperature increases have been greater in higher latitudes. For example, the average temperature in Canada has increased by 0.8°C during the past 80 years.

Exhibit 1.3

Land Surface and Sea Surface Temperatures, 1861-1994



Source: Adapted from Intergovernmental Panel on Climate Change, *Climate Change 1995, The Science of Climate Change* (Cambridge, U.K.: Cambridge University Press, 1995), Fig. 3.3.

There seems to be little doubt about the causal relationships. Scientists have been able to model the relationships between CO_2 concentrations and their climate effects.

Climate change is not simply global warming. Global warming leads to other types of climate change including:

- rises in sea levels and flooding in coastal areas;
- droughts and desertification in currently inhabited areas; and
- increasing frequency and intensity of extreme weather events such as hurricanes, tornadoes and other types of storms. For example, "Some studies suggest that since the late 1980's, North Atlantic winter storm activity has been more extreme than it ever was in the previous century."[2]

Exhibit 1.4 indicates how the number of natural disasters has been increasing.

Exhibit 1.4

Worldwide Great Disasters *(losses greater than US$100 million)*

Source: Munich Re, *Topic: An Annual Review of Natural Catastrophes*, corporate document (Munich, Germany, 1997).

The Feasibility of Reducing GHG Emissions

The international consensus on the problems of climate change has led to several agreements. In 1992, Canada signed the Framework Convention on Climate Change, agreeing to stabilize its GHG emissions at 1990 levels by the year 2000. Unfortunately, since 1990, GHG emissions in Canada have risen by some 13%. In 1997, Canada signed the Kyoto Protocol and agreed to reduce its emissions to 6% below 1990 levels by the year 2012. Although Canada has not yet ratified the Kyoto Protocol, its signature implies a national commitment.

Attacking emissions through societal action can be successful. The best example is the international effort to phase out the production and consumption of ozone-depleting substances. Since the Montreal Protocol, which came into effect in 1989, many countries have completely phased out the use of the worst offending substances and have agreed to a total phase-out by the year 2015.

This experience confirms that we can affect the amount of GHGs that are emitted by human activity. But the challenge will be great to achieve the agreed targets.

In the remainder of this document, we describe the contribution of urban transportation to GHG emissions and then analyze various possible initiatives to reduce GHG emissions from urban transportation in Canada.

2

Role of Urban Transportation in the Production of Greenhouse Gases

The purpose of this section is to provide the most accurate description possible, from available information, of the role and importance of urban transportation in the production of greenhouse gases (GHGs) in Canada today and to describe future emissions.

Transportation Accounts for 26% of All GHG Emissions

In 1995, the total level of GHG emissions was estimated to be approximately 619 million tonnes (MT), expressed on a carbon dioxide (CO_2) equivalent basis. Exhibit 2.1 provides a breakdown of the sources of GHG emissions in Canada. The emissions are shown in CO_2 equivalents, which take into account the combined impact of CO_2, methane and nitrous oxide. The CO_2 equivalent is 21 tonnes for 1 tonne of methane and 310 tonnes for 1 tonne of nitrous oxide. CO_2 is by far the largest component of GHG emissions from transportation and accounts for about 92% of total GHG emissions. As shown in Exhibit 2.1, transportation is the largest single source of GHG emissions, accounting for 26% of these emissions.

According to Natural Resources Canada projections, which form the basis of Exhibit 2.1, total GHG emissions from all sectors in Canada are expected to rise from 619 MT in 1995 to 669 MT in the year 2010 if no initiatives to reverse current trends are taken. This represents an increase of about 8%, or an average annual growth rate of 0.5%. GHG emissions from transportation sources are expected to rise from 163.5 MT in 1995 to 188 MT in 2010, an increase of 15%. Compared with 1990 levels, emissions from all transportation sources are forecast to increase by 26%. Figures developed for this report suggest that growth in urban transport emissions may be less (22% increase compared to 1990 levels) due to the lower proportion of air travel and truck travel, the fastest growing sectors.

Exhibit 2.1

Transportation's Contribution to GHG Emissions
(million tonnes CO_2 equivalent)

End Use Sector	1990	1995	2010	1995 share	Average Annual Growth Rate 1995-2010
Residential	44.1	47.1	38.4	8%	-1.4%
Commercial	26.2	28.7	33.0	5%	0.9%
Industrial	90.1	98.0	117.3	16%	1.2%
Transport	149.2	163.5	188.0	26%	0.9%
Subtotal	*309.6*	*337.3*	*376.7*	*55%*	*0.7%*
Electricity generation	95.1	103.1	110.1	17%	0.4%
Fossil fuel production	83.4	101.6	96.2	16%	-0.4%
Total energy-related	*488.1*	*542.0*	*583.0*	*88%*	*0.5%*
Total non-energy-related	75.9	76.6	85.7	12%	0.8%
Grand Total	**564.0**	**618.6**	**668.70**	**100%**	**0.5%**

Source: Transport Canada, Environment Canada, Natural Resources Canada, Department of Finance Canada and Industry Canada, with the assistance of Marbek Resource Consultants, *Foundation Paper on Climate Change — Transportation Sector Initial Draft* (Ottawa, June 1998).

Passenger Transportation Accounts for Over 60% of GHG Emissions from Transportation Sources

It is not surprising that the largest single source of GHG emissions from transportation is the automobile. As shown in Exhibit 2.2, in 1995 automobiles and light trucks accounted for 54% of all GHG emissions from transportation sources. When transit, air and marine modes are taken into account, passenger transportation accounts for approximately 63% of all GHG emissions from transportation sources. The remaining 37% of GHG emissions are due to the movement of freight, with diesel trucks making up the largest component.

Exhibit 2.2

Total GHG Emissions by Transportation Mode, 1995
(million tonnes CO_2 equivalent)

Mode	GHG Emissions (MT 1995)	1995 Share (MT 1995)
Passenger Transportation		
Cars and light trucks	81.6	54%
Urban and intercity bus and rail	2.0	1%
Air[a]	10.3	7%
Marine	0.7	0%
Total Passenger	**94.5**	**63%**
Freight Transportation		
Diesel trucks	26.6	18%
Gasoline trucks	13.7	9%
Rail	5.7	4%
Air[a]	2.6	2%
Marine	6.8	5%
Total Freight	**55.4**	**37%**
Total Transportation (excluding "Other" category)	**149.9**	**100%**
Other/off-road (non-rail) transport	13.6	
All Transportation	**163.5**	

Note:

[a] Assumes 80% of air travel is due to passenger transportation.

Source: J. Lawson, *Canada's Commitment on Greenhouse Gas Emissions under the Kyoto Protocol and the Potential for Reductions in Transport,* presented at the Canadian Transportation Research Forum 33rd Annual Conference, Edmonton, Alberta, May 25-28, 1998.

The Top 13 CMAs Account for More Than Half of All Travel Activity in Canada

In 1996, 62% of Canada's population lived in one of the 25 Census Metropolitan Areas (CMAs) and 54% resided in the top 13 CMAs.[3] About one-third of the population resided in one of the three largest CMAs: Montreal, Toronto and Vancouver. It is clear that Canada's urban population represents the most significant market to target in terms of achieving GHG emission reductions from the transportation sector.

Urban transportation has been defined in many different ways. Since the focus of this study is urban transportation, it is necessary to develop a fairly strict definition of urban travel. For transit modes, it is quite easy to distinguish between urban and intercity travel based on the statistics of the individual carriers. The difficulty lies in defining urban travel for autos (e.g., light vehicles) and freight modes. For the auto modes, a general definition has been developed that includes all auto travel made by residents living in urban areas. For the purposes of this study, urban areas are defined as the 13 most populated CMAs in Canada. Under this definition, urban travel would include intercity auto trips made by urban dwellers. This definition was chosen because many of the policies (e.g., fuel pricing) examined in this report would affect all travel made by an urban resident.

For freight transportation, all activity by non-road modes (e.g., rail, marine and air) has been assumed to be non-urban. For road freight, an informed estimate of transportation activity and emissions according to urban and non-urban sources was made. Based on information from urban cordon counts, it can be estimated that roughly 20% of all vehicle-kilometres driven by diesel trucks are in urban areas (e.g., the 13 largest CMAs). For heavy-duty gasoline trucks, it was assumed that the ratio of urban to non-urban would be similar to that of automobiles and closely related to population and economic activity.

Passenger Transportation in Canada, 1995
(billions of passenger-kilometres)

Location	Automobiles and Light Trucks		Surface Bus		Rapid Transit		Passenger Rail		Total	
	Billion pkt	%	Billion pkt	%	Billion pkt	%	Billion pkt	%	Billion pkt	%
Top 13 CMAs	228.8	56%	9.3	71%	4.8	100%	2.6	63%	245.4	57%
Remaining 12 CMAs	29.4	7%	0.7	5%	0.0	0%	0.0	0%	30.0	7%
Rest of Canada[a]	148.1	36%	3.2	24%	—	—	1.5	37%	152.8	36%
All of Canada	**406**	**100%**	**13.1**	**100%**	**4.8**	**100%**	**4.1**	**100%**	**428**	**100%**
Modal share	95%		3%		1%		1%		100%	

Notes:

pkt = passenger-kilometre-travelled

[a] Transit and rail modes include intercity trips.

Exhibit 2.3 provides a summary of passenger transportation activity by mode based on estimates developed for this study. As shown, the 13 largest CMAs in Canada (based on 1996 population) account for 57% of all passenger transportation activity (excluding aviation and marine modes). The remaining 12 CMAs account for 7%, while the rest of Canada, considered here to be non-urban, accounts for 36%. Automobiles and light trucks account for the largest portion of both urban and non-urban activity.

Exhibit 2.4 provides a similar breakdown of freight tonne-kilometres by mode. Since most air and marine freight cargo is international, these modes are not shown in the comparison. Also, marine and air modes do not enter into the analysis of policy options.

When compared on a tonne-kilometre basis, rail freight accounts for the largest portion of all freight movement in Canada. This is consistent with results presented elsewhere.[4] Heavy-duty diesel vehicles dominate the road freight modes, accounting for about 41% of all freight tonne-kilometres on a national basis. As shown previously, diesel trucks, most of which are heavy-duty vehicles, are responsible for the majority of GHG emissions from freight movement. Therefore, improving the efficiency of freight movement by diesel trucks represents a potential source for achieving significant GHG reductions.

Exhibit 2.4

Freight Transportation in Canada, 1995

(billions of vehicle-kilometres and tonne-kilometres)

Location	HDDV	HDGV	LDDT	LDGT[a]	Rail	Total
All of Canada						
Vehicle-km (billions)	26.9	2.0	2.1	13.4	—	44.3
Tonne-km (billions)	214.8	15.6	2.1	6.7	282.2	521.5
Urban Canada[b]						
Tonne-km (billions)	43.0	8.7	1.2	3.8	—	—
Modal share of tonne-km (All of Canada)	41.2%	3%	0.4%	1.3%	54.1%	100%

Notes:

HDDV = heavy-duty diesel vehicle; HDGV = heavy-duty gasoline vehicle
LDDT = light-duty diesel truck; LDGT = light-duty gasoline truck

[a] 20% of all LDGT vehicle-kilometres are assumed to be for commercial or freight purposes.
[b] 20% of all diesel tonne-kilometres and 56% of all gasoline tonne-kilometres are estimated to be urban.

Sources: Primarily based on information from Environment Canada, *Trends in Canada's Greenhouse Gas Emissions, 1990-1995* (Ottawa, April 1997), p. 17. Rail tonne-kilometres were obtained from Transport Canada reports.

Conclusion — Urban Transportation Is Responsible for About 10% of All GHG Emissions

Exhibit 2.5 provides a breakdown of total GHG emissions in Canada from all sources, ending with the total GHG emissions from urban transportation. As discussed previously, it is estimated that about 619 MT of GHGs were produced in Canada in 1995. Of this, transportation is directly responsible for 26%, or about 163.5 MT. About 92% of the emissions from transportation are attributable to road, rail, marine and aviation modes. The remaining 8% are due to other transportation sources, specifically off-road ground (non-rail) mobile sources.

Based on figures developed by Transport Canada staff, it is estimated that passenger transportation is responsible for 63% of the GHG emissions, and freight transportation is responsible for 37%.[5] Of the passenger transportation emissions, the automobile is by far the largest contributor. For freight modes, diesel trucks, which are primarily used for heavy-duty freight movement, are the primary contributor, although rail, marine and aviation modes make up a significant portion of emissions.

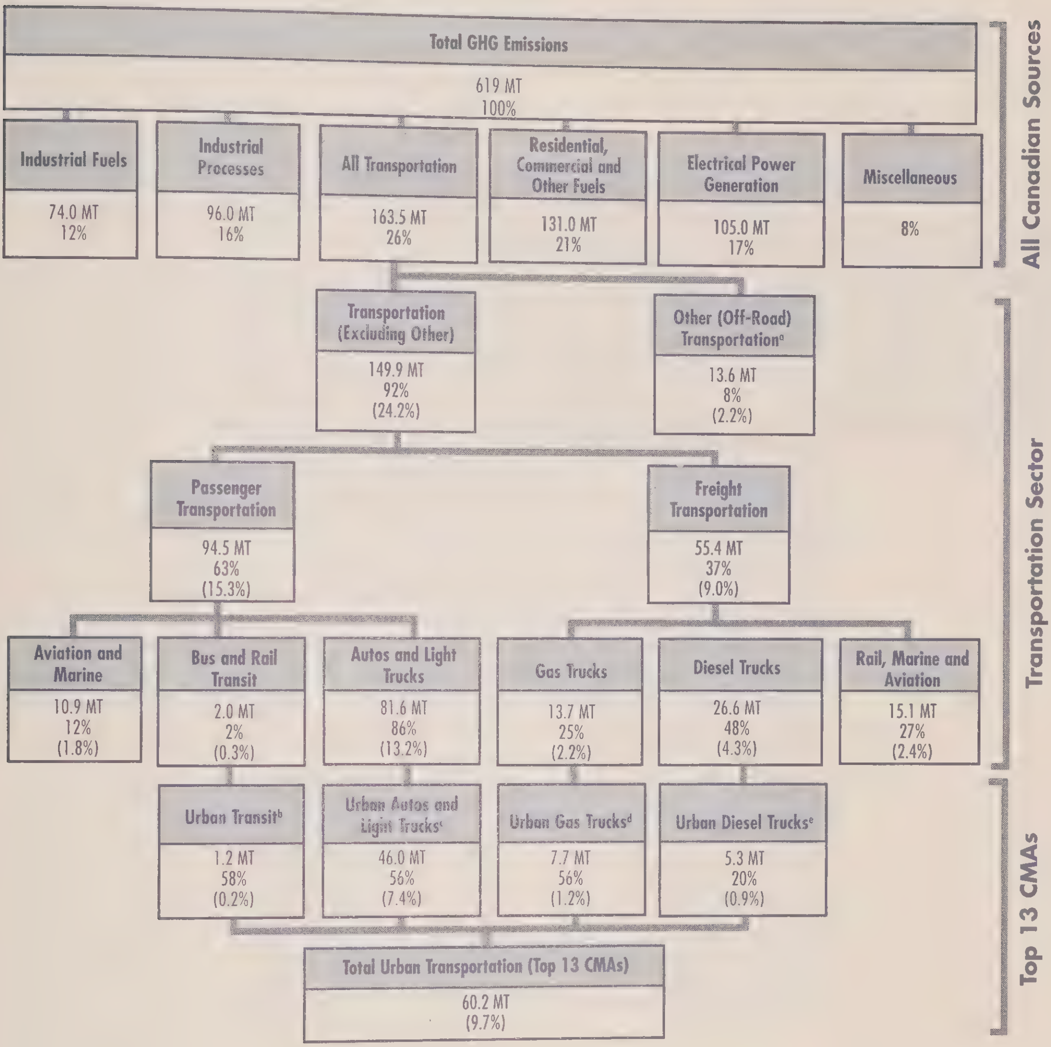
A number of assumptions, which are described above, were required in order to estimate the percentage of activity, and subsequently GHG emissions, that can be attributed to urban transportation. Of primary importance is the fact that this study has defined urban transportation on the basis of the 13 most populated CMAs in Canada. For the bus and passenger rail modes, it is estimated that about 58% of all transportation-related GHG emissions are from urban sources. For auto modes, about 56% of the GHG emissions come from urban use.

Based on all of the assumptions, it can be concluded that transportation in the top 13 CMAs in Canada is responsible for nearly 10% of all GHG emissions in Canada. If all 25 CMAs were included, as well as smaller cities and towns, the total would be greater.

Exhibit 3.5

Urban Transportation and GHG Emissions, 1995

(million tonnes CO_2 equivalent)



Urban GHG emissions in 13 CMAs as percent of total transportation = 37%
Urban GHG emissions as percent of total transportation (excluding other) = 40%
Urban GHG emissions as percent of total transportation (excluding other, rail, aviation and marine) = 49%

Notes:

(xx%) = percent of total GHG emissions

[a] Includes off-road ground (non-rail) mobile sources such as farm tractors, which are not pure transportation.
[b] Based on figures from Transport Canada, representative of emissions for 13 CMAs.
[c] Based on emissions for the top 13 most populated CMAs (54% of Canada's population).
[d] Urban ratio for gas trucks assumed to be similar to that of autos and light trucks.
[e] Subjective estimate based on professional judgment.

3

Development and Assessment of Options to Reduce CO_2 Emissions

There are literally hundreds of measures that individuals, businesses and governments can take to reduce carbon dioxide (CO_2) emissions from urban transportation. On the other hand, the transportation sector presents a formidable challenge precisely because decisions that affect carbon emissions are diffused so thoroughly in the daily activities of all Canadians.

In many cases, measures originally aimed at achieving other social, economic and environmental goals result in carbon emission reductions as a collateral benefit. Vehicle inspection and maintenance programs designed to reduce emissions of smog precursor and particulate pollutants are examples.

The Walking School Bus movement, in which parents organize themselves to supervise groups of children walking to school, is another example. The initial motivation was the safety and security of children, as well as physical exercise and social contact within the neighbourhood. Reducing the need for children to be driven to school also reduces CO_2 emissions, congestion and air pollution by removing cars from the streets.

Where they are applied, policies that encourage mixed use, more compact urban development are the result of regional or municipal desires to increase consumer choice, improve quality of life, and reduce congestion and public infrastructure costs. Such policies can reduce automobile dependency by reducing the need for mechanized transportation and making public transit, walking or cycling more attractive.

Some key themes are emerging from the international research on sustainable transportation, including the NRTEE's 1997 *State of the Debate on the Environment and the Economy: The Road to Sustainable Transportation in Canada*, and from political events such as the Kyoto Protocol on climate change:

➤ Strong measures will be required if the transportation sector is called upon to contribute proportionally to Canada meeting its Kyoto emissions reduction target — to reduce emissions by 6% relative to 1990 levels within the 2008 to 2012 period — and more challenging targets anticipated beyond 2012.

➤ No single policy, level or department of government or sector of society can solve the problem alone. Many integrated, coordinated and mutually reinforcing actions will be required. Options should be considered in a framework of four elements of an emerging strategy for sustainable transportation:

- public education and awareness;
- cooperation among all major players — governments, private sector and the public;
- technology; and
- institutional and social changes, for example, changes in land use, transportation facilities, services and pricing, other forms of demand management, more choice of urban transportation modes and more services within neighbourhoods.

- The use of economic instruments to fully cover external costs or to meet specific GHG targets will be necessary if targets are to be met.
- Canadians can take many unilateral actions to reduce CO_2 emissions from urban transportation. However, for certain of the stronger measures, such as gasoline taxes or regulation of fuel economy standards, joint action with the United States will be highly desirable.
- Policy options that appear to be the most effective in reducing carbon emissions from urban transportation are thought by many to be among the most politically difficult to implement in both Canada and the United States.
- "Three forces are at work in Canadian cities:
  - The threat of climate change;
  - Urban air quality as a public health issue;
  - Shrinking municipal budgets.

  These forces can reinforce each other and provide a unique opportunity to introduce change in the way Canadians perceive, develop and use urban transportation."[6]

From Exhibit 2.5 in the previous chapter, it can be seen that urban automobiles and light trucks are responsible for a large portion (76%) of total urban transportation emissions in Canadian urban areas. Even more overwhelming is the fact that automobiles and light trucks are responsible for 97% of GHG emissions for personal travel. Urban transit, despite substantial, long-term public financial support, has been losing market share to the automobile for many years.

It seems clear, therefore, that any strategy or plan for meeting the Kyoto target in the 2008 to 2012 period must start with strong policy measures aimed directly at motivating consumers and businesses to reduce fossil fuel consumption from light-duty road vehicles. As this section will show, the strongest individual policy options available are economic instruments. Improved technology will be a major way of achieving reductions in GHG emissions; many of the economic measures described are intended to stimulate and/or accelerate the development and implementation of improved technology.

Policy options that facilitate the expansion of public transit and other more sustainable urban transportation options should be considered supporting policies to the main objective of more responsible, constrained use of road vehicles. Provision of such alternatives, as road vehicle use is reduced, will be essential to the future economic, social and environmental health of urban Canada.

This report draws on many Canadian, European, Organization for Economic Cooperation and Development (OECD), and U.S. literature sources. There is a rich body of work in the industrialized world on the policy options discussed in this report. In particular, the U.S. literature is relevant to the development of a Canadian strategy

for urban transportation, because of the tight integration that already exists in the road transportation manufacturing and operating sectors in the two countries. The success of a Canadian urban transportation strategy can be strongly influenced by the Kyoto strategy of the United States and the product and marketing decisions of automobile and truck manufacturers selling in the North American market.

The policy options chosen for reducing CO_2 emissions from urban transportation to meet the Kyoto target will require dramatic reductions from road vehicles. In the section below, policy options that directly influence road vehicle use and emissions characteristics are assessed. The section that follows reviews policy options that indirectly influence road vehicle use by encouraging expansion of alternative means of social and economic exchange within urban regions. The latter are discussed under the categories of Enhanced Public Transit, Land Use/Urban Design and Other Transportation Demand Management Policy Options.

Reducing CO_2 Emissions from Road Vehicles

This section and the next present and evaluate various options for reducing CO_2 emissions. The potential reductions are evaluated for the year 2010 (2010 was chosen as the target year in all the modelling exercises in this report, since it is the midpoint of the Kyoto target period of 2008 to 2012). Baseline forecasts for 2010 were developed by extrapolating 1995 emissions using Natural Resources Canada's growth factors. Emissions for 2010 were estimated to be 45.6 million tonnes (MT) for urban passenger travel and 2.9 MT for freight movement. These forecasts include assumptions about improvements in technology on a business-as-usual basis. The projections of vehicle emissions prepared by Natural Resources Canada and used as the baseline scenario include assumptions about the relationship between overall fuel consumption and gross domestic product/personal income over the horizon period of this study. No additional analyses of these relationships were undertaken in this study.

Fuel Taxes

Gasoline Taxes

Gasoline price has a direct impact on fuel consumption. In North America, there was strong market reaction to the oil shocks of the 1970s, as consumers reduced automobile use and moved to more fuel efficient vehicles.[7] Today in Europe and Japan, with much higher gasoline prices, per capita fuel consumption is approximately one-third that of Canada and the United States. Higher population densities in Europe and Japan reduce per capita vehicle use. In addition, average or fleet-wide fuel economy ratings of North American vehicles are lower than those of offshore competitors, reflecting historically lower fuel prices relative to Europe and Japan.

Gasoline taxes are considered by many to be among the strongest and most economically efficient policy options that can be applied to reduce fuel consumption and CO_2 emissions. Because gasoline price directly affects the cost of driving, it can influence a broader range of consumer and business decisions than most other policy options.

Research suggests that consumers constrain their decisions about transportation within a total budget for acquisition and operation that is a fixed percentage of their total incomes.[8] The short-term response to fuel price increase is reduced vehicle use (vehicle-kilometres travelled [vkt]). In the longer term, fuel taxes affect consumer choices of where to live and work, as well as vehicle manufacturers' decisions on the fuel economy of their products through vehicle design, cost effective technology uptake and marketing strategies.

The Canadian market for light-duty vehicles represents approximately 8% of the total North American market. Decisions by vehicle manufacturers to incorporate cost effective technologies for improving the fuel economy of their products would be much more sensitive to a harmonized, North America-wide gasoline tax policy than they would to a gasoline tax policy applied only in Canada.

For a Canada-only gasoline tax, the impact on CO_2 emissions, even over the long term, would likely be limited to reducing vkt and to vehicle downsizing. Both vehicle size and average vehicle fuel economy rating (vehicle size) are already lower in Canada than in the United States, as shown in Exhibit 3.1. This fact suggests that Canada would have limited room to manoeuvre in unilaterally shifting the fleet mix to even smaller vehicles. On the other hand, North America-wide tax increases should stimulate manufacturers to invest in developing new technologies in order to meet anticipated market demand.

In order for a gasoline tax policy to be effective, the research literature indicates that very significant price increases would be required to achieve the Kyoto targets for CO_2 reduction. This assumes proportional reductions from the urban transportation sector will be required, and that there will be a need to establish momentum for greater reductions beyond 2012.

Exhibit 3.1

Passenger Car Segment Share, 1994
(Canada and the U.S.)

Segment	Canada's Share (%)	U.S. Share (%)
Economy	7.3	3.2
Small	34.9	24.6
Compact	16.6	14.1
Midsize	24.5	30.0
Large	5.0	7.4
Luxury	5.9	11.9
Sport	5.8	8.9

Source: The Osborne Group, DesRosiers Automotive Consultants and Pilorusso Research and Consulting, *Reducing Greenhouse Gas Emissions from the Ontario Automotive Sector* (Toronto: Transportation and Climate Change Collaborative, May 1995).

To mitigate economic disruption and allow consumers and industry time to adjust to strong, new market price signals, tax increases would need to be gradual and sustained over a period of many years. Given the underlying uncertainties about the impacts of such a tax policy, an additional benefit of the gradual approach is that it provides opportunities for program modification in response to experience gained with the policy over time.

The United Kingdom provides a current example of a national commitment to a gradual annual gasoline tax increase. In 1993, the U.K. government announced a policy of increasing gasoline prices by 5% each year for the indefinite future. This has now been raised to 6% per year.

Many studies have examined the elasticity of demand between fuel price and fuel consumption. Short-term elasticities relate to the impact of fuel price on vkt by the fleet on the road, and have been found to be in the range of -0.1 to -0.3 (i.e., if gasoline prices rise by 10%, vkt will drop between 1% and 3% in the short term).[9]

A recent University of Toronto study of the impact of fuel price increases on peak period (mostly work-related) automobile travel in the Greater Toronto Area (GTA) found that short-term elasticities were much lower than indicated above.[10] This may reflect modelling method limitations, as discussed by the authors. It may also relate to the inelasticity of work trip origins and destinations and the lack of acceptable transportation alternatives for such trips in the short term. The GTA case study did not address off-peak personal travel, which is a growing percentage of total trips. Personal travel would be expected to exhibit a more elastic response to fuel price increases.

For purposes of this Backgrounder, the following scenarios for light-duty vehicles were assumed for the period 2000 to 2010:

- Scenario 1: gasoline price increases 3 cents/litre annually. This represents an annual increase of about 5.5% relative to current gasoline prices in Canada and is comparable to the annual increases in the United Kingdom, which started in 1993 as a long-term measure to reduce CO_2 emissions.

- Scenario 2: gasoline price increases X cents/litre annually, where X is the increase necessary, as a single measure, to reduce gasoline consumption to meet the Kyoto target (6% below 1990 levels for gasoline vehicles only).

The new vehicle fleet replacement rate (new vehicle sales) is estimated to be 8% per year, with fleet turnover of about 12 years.

Long-term elasticities of demand to fuel price increases were assumed to be:

- vkt = -0.15

- fuel economy of new vehicles
    - vehicle design, technology = -0.25
    - shift in vehicle fleet mix = -0.15[11]

Case A. *Canada-Only Gasoline Tax*

For a Canada-only gasoline tax, the total long-term elasticity of fleet fuel consumption to gasoline price would be the sum of elasticities of vkt and shift in fleet mix. It is assumed that manufacturers would not make vehicle design and technology decisions for the Canadian market only. The long-term Canada-only elasticity is thus assumed to be -0.15 with respect to vkt and -0.15 with respect to the fuel economy of new vehicles.

For Case A, the annual fuel price increase required to meet the Kyoto target (for gasoline vehicles only) would be 5.4 cents/litre.

Case B. *North America-Wide Gasoline Tax*

For a North America-wide gasoline tax, the total long-term elasticity would be -0.15 with respect to vkt and (-0.25 + -0.15) = -0.40 with respect to the fuel economy of new vehicles. This reflects the long-term influence of tax policy on vkt, manufacturers' vehicle design and fuel efficiency technology decisions, and shifts in consumer vehicle purchase decisions. There is some uncertainty about whether the impacts of these three effects are simply additive, but the effect of this uncertainty is considered to be small.

For Case B, the annual fuel price increase required to meet the Kyoto target (for gasoline vehicles only) would be 3.6 cents/litre.

Exhibit 3.2 illustrates the impacts of the scenarios for gasoline tax increases based on the assumptions about the long-term elasticities of vkt and fuel efficiency.

Exhibit 3.2

Impacts of Gasoline Taxes

	Annual CO_2 (Kilotonnes)			Change from 2010 Baseline			Change from 1990		
	Passenger	Freight	Total	Passenger	Freight	Total	Passenger	Freight	Total
1990	39,589	8,390	47,979	—	—	—			
2010 baseline	45,581	12,887	58,468	—	—	—	15%	54%	22%
2010 New Scenarios									
Scenario 1A: Gasoline tax ($0.03/litre annually, Canada only)	40,809	12,332	53,141	-10%	-4%	-9%	3%	47%	11%
Scenario 2A: Gasoline tax ($0.054/litre annually, Canada only)[a]	37,179	11,909	49,087	-18%	-8%	-16%	-6%	42%	2%
Scenario 1B: Gasoline tax ($0.03/litre annually, North America-wide)	38,385	12,066	50,452	-16%	-6%	-14%	-3%	44%	5%
Scenario 2B: Gasoline tax ($0.036/litre annually, North America-wide)[a]	37,029	11,911	48,940	-19%	-8%	-16%	-6%	42%	2%

Note:

[a] These are the price increases that would be required to achieve a 6% reduction in CO_2 emissions from 1990 levels by 2010 for gasoline vehicles only. Most emissions from gasoline vehicles are due to passenger transportation.

If gasoline prices were increased in Canada only, the major impacts would be on vkt and vehicle fleet mix. It is assumed that technology improvements would not proceed as swiftly as with a harmonized, North America-wide tax initiative. The resulting reductions in CO_2 for a 3 cents/litre per year increase would be in the order of 10% compared to the 2010 baseline CO_2 levels for passenger transportation only. If a reduction of 6% from 1990 levels by 2010 were to be achieved for gasoline vehicles only, a 5.4 cents/litre per year increase would be required.

Emissions reductions for a North America-wide increase of 3 cents/litre per year would be significant. Compared to the baseline 2010 scenario, annual CO_2 could be reduced by as much as 16% for passenger transportation. Compared to the 1990 CO_2 levels, the reduction is estimated to be in the order of 3% for passenger vehicles. If a reduction of 6% from the 1990 levels by 2010 were to be achieved for gasoline vehicles only, a 3.6 cents/litre per year increase would be required.

It is assumed that a new gasoline tax policy aimed at reducing CO_2 emissions would be the subject of joint federal/provincial negotiations. The need for federal/ provincial cooperation for such a policy option stems from the fact that both federal and provincial governments currently have gasoline taxation powers, and from the need to ensure a level playing field throughout Canada.

As single occupancy vehicle use is reduced through increased fuel taxes, more sustainable transportation alternatives — such as urban transit and infrastructure for walking and cycling — and other measures for reducing transportation demand must be developed in parallel. Dedicated investment of a portion of revenues from a new gasoline tax policy has often been suggested as a funding mechanism for reducing demand. Indeed, the way in which such funds are re-invested could have an impact on long-term emissions reductions.

Gasoline tax increases on the scale necessary to provide strong incentives for reduced fleet fuel consumption would generate very large amounts of tax revenue. The gross revenues (in 1998 dollars) for the year 2010 generated from increased gasoline taxes for each of the four scenarios are shown below. For both the Canada-only and North America-wide scenarios, the revenues are from gasoline sold only in the 13 largest CMAs in Canada.

- **Scenario 1A:** Gasoline tax ($0.03/litre annually, Canada only) = $5.49 billion
- **Scenario 2A:** Gasoline tax ($0.054/litre annually, Canada only) = $8.91 billion
- **Scenario 1B:** Gasoline tax ($0.03/litre annually, N.A.-wide) = $5.15 billion
- **Scenario 2B:** Gasoline tax ($0.036/litre annually, N.A.-wide) = $6.05 billion

Such revenue increases could be used to reduce other tax rates such as personal or corporate income taxes to deal with social equity and competitiveness issues. Many commentators have suggested that the cause of economic efficiency would be better served by taxing consumption to reflect true external costs, than by taxing income and other wealth-generating activities. Such a fundamental change in the structure of tax policies would require dialogue among all levels of government in Canada.

Diesel Fuel Taxes

There is limited research reported in the literature on elasticities of diesel fuel consumption to fuel price. For purposes of this study, we have used a figure of -0.2 reported by Michaelis to project CO_2 emissions reduction for 2010 from a 3 cents/litre annual fuel price increase starting in 2000.[12]

Unilateral imposition of a large annual diesel fuel tax in Canada for trucking could have major impacts on the international competitiveness of Canadian trucking firms. For this Backgrounder, it has been assumed that such a tax would only be introduced as a harmonized tax in cooperation with the United States. At present, there is no indication that such a tax is being seriously considered in the United States.

The estimated reductions for a 3 cents/litre annual diesel fuel price increase are shown in Exhibit 3.3. It is important to note that the reductions shown are for the urban portion of road freight transport only. For a North America-wide diesel fuel tax, the potential emissions reduction would be much more significant, given that most road freight movement takes place outside urban areas. If only road freight modes are considered, the CO_2 reduction would be 8% compared to the 2010 baseline. This estimate is based on an elasticity that does not take into account modal shifts in freight tonne-kilometres and the possible emissions implications of this.

Exhibit 3.3

Impacts of Diesel Fuel Tax

	Annual CO_2 (Kilotonnes)			Change from 2010 Baseline			Change from 1990		
	Passenger	Freight	Total	Passenger	Freight	Total	Passenger	Freight	Total
1990	39,589	8,390	47,979	—	—	—			
2010 baseline	45,581	12,887	58,468	—	—	—	15%	54%	22%
2010 New Scenario Diesel tax ($0.03/litre annually, North America-wide)	45,522	11,920	57,443	-0.1%	-8%	-2%	15%	42%	20%

Corporate Average Fuel Efficiency/ Corporate Average Fuel Consumption

Corporate Average Fuel Efficiency

The U.S. Corporate Average Fuel Efficiency (CAFE) is a regulatory instrument under which each automobile manufacturer is required to meet a common fuel efficiency standard, averaged over all of the vehicles sold by that manufacturer in a model year. The U.S. government introduced legislation imposing CAFE standards in 1975, in response to the Organization of Petroleum Exporting Countries oil shock of the previous year. The standards were set to move new passenger car fuel economy from a standard of 18.0 miles per gallon (mpg) (13.1 litres/100 kilometre [km]) starting in 1978, to 27.5 mpg (8.7 litres/100 km) in 1985. The latter standard remains in effect today.

Separate, less aggressive standards were set for two-wheel drive and four-wheel drive light-duty trucks, including minivans and sport-utility vehicles. The current average CAFE standard for all light-duty trucks is 20.2 mpg (11.8 litres/100 km). When these standards were set, the majority of light trucks were used for commercial purposes. Light trucks then represented about 15% of the total light-duty vehicle fleet on the road. At that time, the lower standard for this class of vehicle was not seen as a major barrier to the overall success of the CAFE program.

Today, however, light-duty trucks represent approximately 50% of new vehicle sales. This growth, compared with relatively flat sales of cars, reflects increased use of trucks as personal vehicles. The lower fuel efficiency standard for light trucks has tended to offset the gains in fuel consumption expected from CAFE for the overall vehicle fleet.

Corporate Average Fuel Consumption

Since 1980, the Canadian government, under a memorandum of understanding with automobile manufacturers, has had a voluntary Corporate Average Fuel Consumption (CAFC) program in place. CAFC mirrors the U.S. CAFE standards. Because of higher fuel prices and lower disposable income in Canada, the Canadian light-duty vehicle fleet mix is biased toward smaller, more fuel efficient vehicles. As a result, the fuel efficiency of the Canadian fleet has been slightly higher than in the United States since the early 1980s.[13] In 1993, the average Canadian passenger car fleet fuel efficiency was 29.4 mpg (8.0 litres/100 km) compared with the U.S. average of 28.3 mpg (8.4 litres/100 km).

Experience with CAFE/CAFC

Overall fuel consumption by the light-duty vehicle fleet is a function of both average fuel efficiency and how much the vehicles are used. CAFE/CAFC places responsibility for increased fleet fuel efficiency on vehicle manufacturers. Manufacturers, acting rationally, may respond by reducing the weight of the new vehicles, incorporating fuel efficiency technologies within the cost constraints of the discounted value of fuel savings to the consumer, or increasing prices of larger vehicles and lowering the prices of smaller, more fuel efficient products. The U.S. literature indicates that all of these strategies have been used.

Many commentators have credited CAFE standards with having improved fuel efficiency from 19.9 mpg (11.8 litres/100 km) in 1978 to 28.8 mpg (8.2 litres/100 km) in 1988. However, in the years prior to 1981, it has been shown that fleet fuel efficiency improved as a result of market demand, as consumers reacted to higher gasoline prices following the first oil shock of 1974, and the expectation that fuel prices would remain high.[14] After 1981, manufacturers did respond to CAFE standards as gasoline prices in the United States fell to the post-World War 2 levels that persist today. It has been estimated that fuel efficiency gains from CAFE offset the increases in vkt caused by the drop in fuel prices in the years following 1981.

It has also been established that manufacturers did raise prices of larger vehicles and lower those of smaller vehicles in this period as a strategy for compliance with CAFE.[15] In the 1983 to 1993 period, analysis has shown that the price charged for additional weight doubled after 1983 and the price for acceleration more than tripled.

There is some controversy about the relationship between how fast manufacturers apply new technology and real and expected changes in fuel prices. Some argue that CAFE seems not to have been a major factor in the fuel efficiency technology decisions of the car makers. Crandall and Nivola state that "the decided slowdown in technical progress in achieving efficiency, evident in the 1990's, is strongly correlated with declining (fuel) prices (in the U.S.) over the 1980's. Apparently vehicle producers are unwilling to commit to expensive new technology to save fuel in an environment of falling gasoline prices."[16] The counter-argument is that "there have been very significant technological changes to cars in the past decade in spite of falling fuel prices, and these changes have essentially allowed fuel economy to stay flat as consumers have shifted to larger, more luxurious vehicles."[17]

In summary, it appears that CAFE/CAFC standards affect the weight of vehicles sold, while fuel efficiency technology application is more sensitive to fuel price.

CAFE/CAFC standards have a number of other characteristics that affect their overall effectiveness:

- In a period of stable or falling gasoline prices there is a take-back effect, in which consumers respond to lower gasoline costs by driving more. This effect is estimated to be in the range of 15% to 30%, meaning that a 1% improvement in fuel efficiency results in increased vkt of 0.15% to 0.30%.

- As vehicle manufacturers reduce the price of smaller vehicles under CAFE/CAFC, some analysts suggest that the number of new vehicles sold increases. Others argue that raising prices of new vehicles to meet CAFE/CAFC regulations causes some consumers to delay replacing older, less fuel efficient vehicles, thus further undermining the intent of the regulation.

- The experience of CAFE/CAFC in the 1980s has generated strong opposition to new or extended standards by the Big Three automobile manufacturers and U.S. autoworker unions. The reason for this opposition is straightforward. The products of North American automobile companies have historically been larger and less fuel efficient than those of Japanese competitors. Under CAFE, each manufacturer was required to meet the same standard for each major class of light-duty vehicle in a given model year. This had a negative effect on the competitiveness of

domestic manufacturers in their home markets. When CAFE was first imposed, North American manufacturers' average fleet fuel efficiency for cars was 18.7 mpg (12.6 litres/100 km) compared with the Japanese average of 27.9 mpg (8.4 litres/100 km). By 1993, the gap had narrowed, with the U.S. domestic average for cars close to the standard of 27.5 mpg (8.5 litres/100 km), compared with the import average of 29.4 mpg (8.0 litres/100 km), still 2 mpg better than the Big Three.

- Because of their economic inefficiencies, and specifically their inability to contribute to reduced vkt, some analysts have concluded that CAFE/CAFC standards have a larger economic cost than a gasoline tax designed to produce the same reduction in energy use.[18] The issues of economic efficiency and impacts are discussed later in this report.

For this Backgrounder, estimates of the CO_2 emissions for urban transportation in Canada were made for the two cases of Canada-only and North America-wide applications of CAFE/CAFC. These estimates were made using the following assumptions:

- New standards are set in 2002 in both countries for all classes of light-duty vehicles, with the first annual increment taking effect in the model year 2005. New vehicle fuel efficiency for each major class of light-duty vehicle improves 1% annually when applied in Canada only and 2% annually when applied North America-wide.[19] Again, the reason that North America-wide measures are more effective is that they will stimulate technological innovation much more than measures that are applied in Canada only.

- The fuel efficiency of new vehicles improves at the base forecast rates adopted by Natural Resources Canada in the absence of new policy intervention by government,[20] until the new CAFE/CAFC standards take effect in 2005. For automobiles, this rate is -0.66% per year.

- A take-back effect of one-third has been assumed to account for the fact that people may drive further because they are using less fuel.

Alternative forms of new CAFE/CAFC standards have been proposed in the literature:

- tradable CAFE permits;

- a national new vehicle fuel economy standard to be met by manufacturers collectively, with individual manufacturers' targets determined through negotiation;

- CAFE standards combined with feebates, or with "gas guzzler" taxes; and

- CAFE standards that depend on the type of car sold — for example, allowing higher average fuel consumption for the product mix of manufacturers that produce larger vehicles.

The OECD suggests that the use of tradable CAFE permits would be the most economically efficient approach to imposing economy improvements on manufacturers.[21]

The impacts of CAFE/CAFC standards in the horizon year 2010 are shown in Exhibit 3.4. In estimating the impacts, the fact that the CAFE standards would apply to new vehicles only has been taken into account. Assuming a fleet replacement rate of 8% per year, roughly 48% of the vehicle fleet would be replaced by 2010, all operating with varying degrees of CAFE standards, depending on the year they were built.

The impacts of CAFE/CAFC standards are relatively minor given that the standards do not start taking effect until 2005, and even then apply to new vehicles only. The estimated reduction in CO_2 levels due to CAFC for passenger vehicles is roughly 1.4% compared to the baseline 2010 projections. The impacts of CAFE standards would be about twice that at 2.5%.

Exhibit 3.4

Impacts of CAFE and CAFC in 2010

	Annual CO_2 (Kilotonnes)			Change from 2010 Baseline			Change from 1990		
	Passenger	Freight[a]	Total	Passenger	Freight[a]	Total	Passenger	Freight[a]	Total
1990	39,589	8,390	47,979	—	—	—			
2010 baseline	45,581	12,887	58,468	—	—	—	15%	54%	22%
2010 New Scenarios									
Canada only: 1% annual improvement taking effect in 2005 (new vehicles only)	44,930	12,840	57,770	-1.4%	-0.4%	-1.2%	13.5%	53%	20%
North America-wide: 2% annual improvement taking effect in 2005 (new vehicles only)	44,433	12,792	57,225	-2.5%	-0.7%	-2.1%	12.2%	52%	19%

Note:

[a] Applied to light-duty freight only.

Since the CAFE/CAFC standards would not be implemented until 2005, their ultimate potential is significantly underestimated when examined for a 2010 horizon. In order to demonstrate the longer term impacts of CAFE/CAFC standards, the effects have been extended to the year 2020. As shown in Exhibit 3.5, the impacts of CAFE/CAFC standards are much more significant after several years, based on the assumption that the 2% annual improvement will continue as long as the standards are in place. Using 2020 as the comparison year, the impact of a Canada-only CAFC standard would be roughly a 10% reduction in CO_2 from the baseline estimate for passenger transport. A North America-wide standard would result in a reduction of about 15% from the baseline. This is why policy makers should think about implementing CAFE standards in the very near future.

Exhibit 3.5

Impacts of CAFE and CAFC in 2020

	Annual CO_2 (Kilotonnes)			Change from 2010 Baseline			Change from 1990		
	Passenger	Freight[a]	Total	Passenger	Freight[a]	Total	Passenger	Freight[a]	Total
1990	39,589	8,390	47,979	—	—	—			
2020 baseline	48,640	15,388	64,028	—	—	—	23%	83%	33%
2020 New Scenarios									
Canada only: 1% annual improvement taking effect in 2005 (new vehicles only)	40,928	12,509	53,436	-10.2%	-2.9%	-8.6%	3.4%	49%	11%
North America-wide: 2% annual improvement taking effect in 2005 (new vehicles only)	38,742	12,298	51,041	-15.0%	-4.6%	-12.7%	-2.1%	47%	6%

Note:

[a] Applied to light-duty freight only.

Feebates

A feebate is an economic policy instrument under which vehicles are subject to taxes or rebates in proportion to how much they exceed or fall below a specified reference energy factor. Typically this factor is the mean fuel economy rating for the vehicle fleet for a particular year. Feebates can be designed to be revenue neutral or to generate sufficient revenue to cover their administrative costs.

Feebates have been extensively researched, especially in the United States, but have not been implemented in a substantive way in any jurisdiction.

Feebates provide a strong market-based incentive to consumers to purchase more fuel efficient vehicles. They provide no direct incentive to reduce vkt. In fact, by increasing the percentage of smaller, more fuel efficient vehicles on the road, they could induce a take-back effect for the same reason as CAFE/CAFC standards.

In response to feebates, consumers who are not prepared to purchase smaller vehicles can be expected to delay purchase decisions in the face of higher replacement costs for older, less fuel efficient vehicles.

In theory, if applied across North America, feebates provide manufacturers with incentives to incorporate fuel efficiency technologies into their products. As in the case of CAFE/CAFC, feebates can also influence the weight of new vehicles and the fleet mix. For a feebate applied only in Canada, the impact would be limited to changing the fleet mix as consumers switched to smaller vehicles. A North America-wide measure would be more effective in stimulating technological innovation.

Ontario's Tax for Fuel Conservation (TFFC), introduced in 1989, is considered a feebate scheme. However, it applies to a very small percentage of new vehicle purchases with highway fuel economy ratings less than 6.0 litres/100 km or more than 9.0 litres/100 km. For the 90% of new vehicles with fuel economy ratings between these two thresholds, a flat tax of $75 applies with no incentive for increased fuel efficiency. Since new vehicles represent only 8% of the road vehicle fleet, the TFFC program only affects about 1% of the fleet in any one year. Exhibit 3.6 shows the schedule of taxes and rebates under the Ontario TFFC program. Note that the rebate of $100 for cars rated at less than 6.0 litres/100 km is a nominal sum that likely has little influence on vehicle purchase decisions. With the exception of the $100 rebate for the most fuel efficient cars, the Ontario TFFC is very similar to the U.S. "gas guzzler" tax. The latter has been shown to have a very small impact on the fleet mix, since it applies to such a small percentage of new vehicle sales.

Exhibit 3.6

Tax Charges and Rebates — Ontario Tax for Fuel Conservation

Rated Highway Fuel Economy (litres/100 km)	Feebates (Taxes and Rebates) ($)	
	Passenger Cars	Sport-Utility Vehicles
Less than 6.0	(100)	0
6.0-7.9	75	0
8.0-8.9	75	75
9.0-9.4	250	200
9.5-12.0	1,200	400
12.1-15.0	2,400	800
15.1-18.0	4,400	1,600
Over 18.0	7,000	3,200

Source: Apogee Research, *A Policy Instrument Working Paper on Reducing CO_2 Emissions from the Transportation Sector in Ontario* (Toronto: Transportation and Climate Change Collaborative, 1995), p. 42.

The following are suggested features of an effective feebate program for Canada. The program would:

- be nationwide;
- have high leverage in the middle of the rated fuel economy distribution of the fleet, where approximately 90% of vehicle sales occur. This can be achieved in the design of a feebate rate schedule, expressed in dollars/litre/100 km;
- set feebate rates high enough to change market behaviour and to meet CO_2 emissions targets; and
- include all classes of gasoline-powered light-duty vehicles including cars, light trucks, sport-utility vehicles and minivans. Strong incentives are needed to improve light truck fuel efficiency, given the impact of lenient fuel economy regulation on truck sales since the 1970s. Separate feebate schedules by vehicle class could also be designed to mitigate the domestic versus import market distortion, since the Big Three have the largest share of the light truck market.

Feebates can be designed to be complementary or act as alternatives to new CAFE/CAFC standards. They can also be integrated with gasoline taxes. These combinations of policies will be discussed in the next section.

Feebates applied across North America would likely have greater impact in Canada than a program applied in Canada only, based on the widely held view that manufacturers are not likely to incorporate advances in fuel efficiency technology into their products for Canada's 8% of the North American market.

To illustrate the potential CO_2 emissions reduction potential of a national feebate program in Canada, estimates of impacts have been made on the following assumptions:

- Case A — Feebates are applied across Canada only.
- Case B — Feebates are applied on a harmonized basis in Canada and the United States.
- The feebate program is introduced in 2005, with five years' notice to manufacturers, and extends to 2010 and beyond.
- Energy reference factor/baseline vehicle fuel economy is 9.0 litres/100 km.
- The estimated effects, by 2010, of feebates of different levels were derived from the literature (see Exhibit 3.7).[22]

Exhibit 3.7

Feebate Options

Feebate Rate C$/litres/100 km (relative to 9 litres/100km)	Expected New Vehicle Fuel Economy Improvement (%)	
	North America	Canada Only
350	10	3
700	14	5
1,400	20	10
2,800	28	18

Note:

The research on which the above figures are based presented the feebate scenarios in U.S. dollars. For this report, the U.S. dollar feebate amounts were converted to Canadian dollars using a multiplier of 1.4.

Source: Based on L. Michaelis, *Annex I Expert Group on the UN FCCC, Working Paper 1, Policies and Measures for Common Action — Sustainable Transport Policies: CO_2 Emissions from Road Vehicles* (Paris: OECD, July 1996), p. 35.

For Canada only, it is assumed that feebates would affect fleet mix only through downsizing. The estimates for North America-wide application include estimated impacts of the feebate on vehicle redesign, additional technology uptake by manufacturers and downsizing.

A range of feebate scenarios is presented in Exhibit 3.8. These show the impacts when feebates are implemented for Canada only, as well as when implemented on a North America-wide basis. For the Canada-only feebate program, the reductions relative to the business-as-usual scenario for 2010 would range from 1% for a $350/litre/100 km feebate to 9% for a $2,800/litre/100 km feebate. The impacts for the same feebates implemented on a North America-wide basis would range from 5% to 14%. Under no scenario would the feebate program alone be able to reduce CO_2 below 1990 levels.

Like CAFE standards, the feebates will not have reached their full potential by 2010, just five years after implementation. Assuming a replacement rate of 8% per year, less than half of the vehicle fleet would be purchased under the feebate program by 2010. However, by 2020, it is likely that most drivers would have purchased at least one vehicle under the feebate program. Therefore, it is reasonable to assume that the impacts of feebates in 2020 would be at least twice as great as the impacts shown in Exhibit 3.8.

Exhibit 3.3

Impacts of Feebates

	Annual CO_2 (Kilotonnes)			Change from 2010 Baseline			Change from 1990		
	Passenger	Freight	Total	Passenger	Freight	Total	Passenger	Freight	Total
1990	39,589	8,390	47,979	—	—	—			
2010 baseline	45,581	12,887	58,468	—	—	—	15%	54%	22%
2010 New Scenarios *Feebates implemented in Canada only*									
C$350/litre/100 km	44,913	12,887	57,801	-1%	0%	-1%	13%	54%	20%
C$700/litre/100 km	44,469	12,887	57,356	-2%	0%	-2%	12%	54%	20%
C$1,400/litre/100 km	43,357	12,887	56,244	-5%	0%	-4%	10%	54%	17%
C$2,800/litre/100 km	41,577	12,887	54,465	-9%	0%	-7%	5%	54%	14%
Feebates implemented North America-wide									
C$350/litre/100 km	43,357	12,887	56,244	-5%	0%	-4%	10%	54%	17%
C$700/litre/100 km	42,467	12,887	55,354	-7%	0%	-5%	7%	54%	15%
C$1,400/litre/100 km	41,133	12,887	54,020	-10%	0%	-8%	4%	54%	13%
C$2,800/litre/100 km	39,353	12,887	52,241	-14%	0%	-11%	-1%	54%	9%

Inspection and Maintenance Programs

Approximately 20% of vehicles on the road, including some vehicles from all model years, are operating at emissions and fuel consumption levels in excess of their rated performance. Annual or biennial inspection and maintenance (I&M) programs have demonstrated that it is possible, at reasonable cost, to identify gross polluters and cause owners to repair their vehicles.

In Canada, British Columbia is the only jurisdiction with an operational I&M program. The B.C. AirCare program, introduced in 1992, applies to approximately one million vehicles in the Lower Fraser Valley. The fuel economy of the cars repaired as a result of the program has improved on average by 7%. As a consequence, gasoline consumption in the region was reduced by 0.73% in the third year of the program.[23] Based on experience in the United States, it is expected that further reductions will be achieved in British Columbia as the AirCare program is modified in future. The B.C. program has been extended to include light- and heavy-duty trucks.

Fuel savings to motorists in the third year of the program have been estimated at about $7 million. The cost of repairs is estimated at $8.7 million. Consumers realize a payback in a little over a year, with the expectation that fuel savings will continue for a number of years.[24]

Ontario has announced that it will implement an I&M program beginning in 1999, starting in the GTA with subsequent extension to other regions of the province by 2002. The Ontario government estimates that when it is in full effect, the province-wide program will reduce annual CO_2 emissions by 0.9 MT.[25]

Quebec has also embarked on a pilot I&M program, announcing a two-year voluntary I&M program in 1997. The program operated from April to October 1997, with voluntary clinics held throughout the province. Voluntary clinics were also held during the summer of 1998. A final report is to be submitted to government officials in the spring of 1999.

I&M programs are now being complemented by advanced on-board vehicle diagnostic systems that, starting in 1996, are being incorporated into new light-duty vehicles. The new systems detect emissions or fuel control component or system failures, provide warning signals to the driver and, for some failures, put the vehicle into a "limp home" mode until repairs are made.

At present, I&M programs have air quality improvement as their primary objective. GHG emissions reductions are a collateral benefit.

For purposes of this Backgrounder, it is assumed that:

- advanced on-board diagnostics systems are in virtually all light-duty vehicles by 2010;
- I&M programs for all classes of light- and heavy-duty road vehicles are in full operation in each of the 13 CMAs covered by this study by 2010; and
- CO_2 emissions reduction from I&M programs is in the range of 1% to 3% of fleet emissions in 2010 compared to baseline emissions in that year.[26]

As discussed above, the emissions reduction potential of vehicle I&M programs has been estimated to be in the order of 1% to 3%. Exhibit 3.9 quantifies the impacts of vehicle I&M programs on urban transportation CO_2 emissions for the lower and upper range. For the purpose of this study, it has been assumed that the reductions from vehicle I&M would encompass all urban transportation modes including urban transit and road freight modes.

Exhibit 3.9

Impacts of Vehicle I&M Programs

	Annual CO_2 (Kilotonnes)			Change from 2010 Baseline			Change from 1990		
	Passenger	Freight	Total	Passenger	Freight	Total	Passenger	Freight	Total
1990	39,589	8,390	47,979	—	—	—			
2010 baseline	45,581	12,887	58,468	—	—	—	15%	54%	22%
2010 New Scenarios									
Impacts assuming 1% reduction in fleet emissions	45,125	12,758	57,883	-1%	-1%	-1%	14%	52%	21%
Impacts assuming 3% reduction in fleet emissions	44,213	12,501	56,714	-3%	-3%	-3%	12%	49%	18%

Vehicle Charges and Taxes

Various different vehicle-related fees and taxes can be used to influence road fleet fuel consumption. They are market-based instruments that can be used as alternative or complementary measures to gasoline taxes, fuel economy standards or feebates.

Annual Vehicle Registration Fees

Annual vehicle registration fees, tied to fuel economy rating or other reference energy factor, can be considered as an alternative to the one-time "gas guzzler" tax applied at time of purchase.

The advantage of the annual registration fee is that it provides a more continual market signal to the consumer throughout the life of the vehicle. The disadvantage is that it does not present the vehicle purchaser with the full financial impact of the "gas guzzler" tax at time of purchase. The annual registration fee does not provide the direct incentive of the feebate, which provides rebates for vehicles with better fuel economy ratings.

Annual registration fees tied to fuel economy and/or emissions, also referred to in the literature as road taxes, are used in Quebec and are also widely used in Europe. In Europe they vary by country and are based on vehicle weight, engine power and fuel type (gasoline or diesel), either individually or in combination.[27] Combined with higher fuel prices, these road taxes can reasonably be credited with contributing to smaller average vehicle size and a more fuel efficient fleet than in North America. France and Denmark levy taxes of 18% and 50% respectively on vehicle insurance premiums.

As with CAFE/CAFC and feebates, vehicle registration fees could be expected to affect vehicle use and fleet mix if used in Canada only.

For the purpose of this study, we have assumed that annual vehicle registration fees would be set to provide the equivalent emissions reduction impact of feebates. The feebates discussed on pages 28-32 ranged from $350/litre/100km to $2,800/litre/100km. These feebates would be assessed on a one-time basis at the time of vehicle sale.

Because feebates would likely be revenue neutral (i.e., some people would pay for being over the limit and some people would benefit from being under the limit), it is difficult to express feebates as a single average value. However, to provide a rough approximation of the equivalent annual value of the feebates (which could be administered as registration fees), the initial value was simply amortized over the average life of a vehicle (12 years). The annual values (calculated using an interest rate of 8%) are shown in Exhibit 3.10.

As indicated in Exhibit 3.10, the average equivalent annual values for the feebates assumed previously range from $46/year/litre/100 km to roughly $372/year/litre/100 km. These values can be interpreted as the annual amount a person would have to pay (or would receive) if he/she purchased a vehicle that had a fuel economy of 1 litre/100 km more or less than the average. For the lower end feebate rates, the annual fee would simply be a token amount. However, in the upper range of the feebate values, the annual equivalent values should have a very measurable impact.

Exhibit 3.10

Annual Registration Fees Required to Provide Equivalent CO_2 Reductions to Feebates

Scenario	Improvement in New Car Fuel Economy	Amount of Feebate at Time of Purchase (for a 1 litre/100 km deviation from the average)	Equivalent Annual Value
C$350/litre/100 km	10%	$350	$46
C$700/litre/100 km	14%	$700	$93
C$1,400/litre/100 km	20%	$1,400	$186
C$2,800/litre/100 km	28%	$2,800	$372

Vkt Charge

An alternative to the gasoline tax instrument is a vkt charge based on odometer readings collected annually during vehicle registration, or automatically at the gas pump. It can affect the amount of vehicle use but provides no incentive for motorists to purchase and use more fuel efficient vehicles, or for manufacturers to offer more fuel efficient vehicles for sale. There are no known applications of vkt charges in any OECD country.

Distance-Based Insurance

Insurance is the second largest motor vehicle operating expense. For a typical vehicle, fuel and oil costs represent about 16% of total annual costs of vehicle ownership and operation compared with 18% for insurance. However, insurance is usually perceived by the consumer as a fixed expense with respect to annual distance travelled. Insurance costs are not seen as a reason to drive less. However, the more a vehicle is driven, the higher are the risks of accidents and insurance claims. Conversely, lower mileage vehicles are subsidizing the insurance costs of those who drive longer distances.[28]

If insurance premiums were tied to distance travelled, they could have an impact on vkt that is similar to an equivalent increase in fuel price through taxation. Alternatively, they could be used to complement a long-term fuel tax strategy. Distance pricing of vehicle insurance could have an impact equivalent to fuel taxes (similar elasticities); it would also be cost effective and more equitable than current annual insurance premiums.

Litman argues that the current price structure of insurance is unfair and inefficient. It is "unfair in terms of horizontal equity because owners of vehicles driven less than average pay more per mile and therefore subsidize higher mileage vehicles. It is unfair

to women, who as a class drive less than men and have fewer accidents. ... It also tends to be unfair in terms of vertical equity because low-income households drive much less than higher income households."[29]

The cooperation of the insurance industry would be essential for this method of collecting premiums. It is likely that distance-based insurance would have to be legislated, since no one company would take the business risk of unilateral action. It could be feasible if the industry saw merit in relating insurance premiums directly to actual vkt.

A practical implementation issue for such a scheme would be the need for an annual odometer audit.

For this Backgrounder, we have estimated the total additional charges that would be required to produce a CO_2 emissions reduction equivalent to a Canada-only gasoline tax. It could be expected that a distance-based insurance program would have somewhat different implications from a Canada-only gasoline tax:

- Consumers would receive an itemization of part of the variable costs of driving at the time of insurance premium payment.
- Inclusion of insurance charges could possibly reduce the vkt tax component of charges required to achieve the equivalent CO_2 emissions reductions of a gasoline tax.

Distance-based insurance has been researched but has not been implemented in any jurisdiction. "[It] has been opposed by the automobile insurance industry because it reduces their marketing opportunities and potential profits. It has been proposed a few times, but has never received broad debate as a travel demand management strategy. Surveys and focus groups indicate that it is among the travel demand pricing options most acceptable by consumers, although high mileage drivers tended to raise minor objections."[30]

Parking Policies

Three basic types of parking policy options can be considered for reducing single occupancy vehicle use and CO_2 emissions:

- changes in parking pricing through tax measures;
- changes in parking supply through regulation; or
- a combination of both of the above.

Parking Pricing Policy

Parking that is free or low in cost to the driver, for work-related and personal trips, is a strong incentive for single occupancy vehicle use. A recent survey in the United States determined that 99% of all automobile trips had a free parking spot waiting at the destination and that 95% of all commuters had free parking at their place of employment.[31]

A study in Los Angeles showed that the average parking cost to the employer was US$3.87 a day.[32] In comparison, the average operating cost for a 36-mile commuting round trip was $2.35. Hence the cost borne by the employer to provide parking represented 62% of the total commuting cost. This suggests that for work-related trips parking pricing could be similar in effectiveness to gasoline tax increases. While the specific costs in Canadian cities differ from those in Los Angeles, it is clear that free parking is a strong factor in road vehicle use and a disincentive for public transit use.

The effectiveness of shifting responsibility for parking costs from employer to employee is illustrated in the results of five studies of parking — four for different parts of the greater Los Angeles region and one for Ottawa.[33] On average, these studies show a reduction of 40% in single occupancy vehicle use when the costs of parking are shifted from employer to employee. In addition, average vehicle occupancy increased from 1.43 to 1.96. In the specific case of Ottawa, single occupancy vehicle use declined by 20% and average vehicle occupancy improved from 2.56 to 3.13.

One way that some employers have found to shift the burden of parking costs to employees is to provide a transportation allowance (say $70 per month) to all employees. Employees who choose to drive vehicles and use company-supplied parking pay $70 per month for the privilege. Others are free to use other means of getting to work and keep part or all of the monthly transportation allowance. Under current rules, such transportation allowances would be treated as taxable benefits in Canada. When the Canadian government imposed a $23 monthly charge for federal government employees' parking in Ottawa, demand dropped by 18%. In Los Angeles, employees of Commuter Computer reduced their use of company-supplied parking by 38% with a US$58 monthly charge.[34]

For this Backgrounder, elasticity of parking pricing to vkt is assumed to be -0.15 for urban regions and -1.0 for the downtown core of the largest cities, including Vancouver, Toronto and Montreal. The elasticity assumption for urban regions is the average derived from the Los Angeles and Ottawa studies.[35] The perfect elasticity of -1.0 for large city cores is derived from a University of Toronto study.[36] This higher elasticity reflects the difference in auto use modal split (31% for downtown versus 62% for the GTA), and the availability of better transit in the core.

It is also assumed that:

- A parking pricing policy is mandated by provincial legislation, since it would have to be applied over entire urban regions to minimize inequity and market distortions.
- Parking pricing policies are applied to all public and commercial parking in the 13 CMAs in Canada.
- Parking prices increase 5% annually relative to the baseline from 2000 to 2010.
- Tax revenues are collected by municipalities and dedicated to other measures that increase the supply and use of more sustainable transportation alternatives.

The impacts of parking pricing were assessed separately for trips to urban areas and for trips to the three largest downtown areas using the elasticities outlined above. Based on data from the Toronto Transportation Tomorrow Survey,[37] it can be concluded that about 5% of all daily auto trips have destinations in downtown Toronto and would be highly elastic to parking prices. For the purpose of this study, this ratio of 5% was applied to Montreal and Vancouver as well.

Exhibit 3.11

Impacts of Parking Policies

	Annual CO_2 (Kilotonnes)			Change from 2010 Baseline			Change from 1990		
	Passenger	Freight	Total	Passenger	Freight	Total	Passenger	Freight	Total
1990	39,589	8,390	47,979	—	—	—			
2010 baseline	45,581	12,887	58,468	—	—	—	15%	54%	22%
2010 New Scenario									
Impacts of 5% annual parking price increase	40,974	12,887	53,862	-10%	0%	-8%	3%	54%	12%

The net impacts of a 5% annual increase in urban parking prices (Exhibit 3.11) are estimated to be in the order of a 10% reduction in CO_2 from the 2010 baseline scenario (passenger transport only). Based on these results, it would appear that parking pricing may have significant potential as a means for reducing urban GHG emissions.

Parking Supply Policy

Parking supply policy relates to the ability of local governments to control the total number of parking spaces available in a given area, thereby influencing the number of vehicles that will be attracted to the area. In addition, local governments can control the availability of specialized parking such as park-and-ride lots or dedicated high occupancy vehicle spaces.

There are many different parking supply measures that can be implemented to reduce the number of vehicles travelling in an area:

- preferential parking for high occupancy vehicles;
- peripheral parking with shuttles;
- on-street controls;
- reduced minimum parking requirements for new development;
- parking maximums; and
- area-wide parking caps.

These measures can influence mode shifting by:

- reducing the number of parking spaces available;
- reducing the time allowed for parking at designated places; and
- improving the availability and attractiveness of commuting by alternative means.

The Urban Council of the Transportation Association of Canada has called for one of the decision-making principles in its New Vision of Urban Transportation to be: "Plan parking supply and price to be in balance with walking, cycling, transit and auto priorities."[38]

Commercial off-street parking is usually on sites awaiting redevelopment. Municipalities regulate parking supply for new development, usually by establishing minimum supply standards. They also regulate commercial off-street parking on redevelopment sites that:

- creates oversupply in the downtown core;
- destroys the regulated balance between supply and demand; and
- results in downward pressure on all-day prices and therefore encourages single occupancy vehicle commuting.

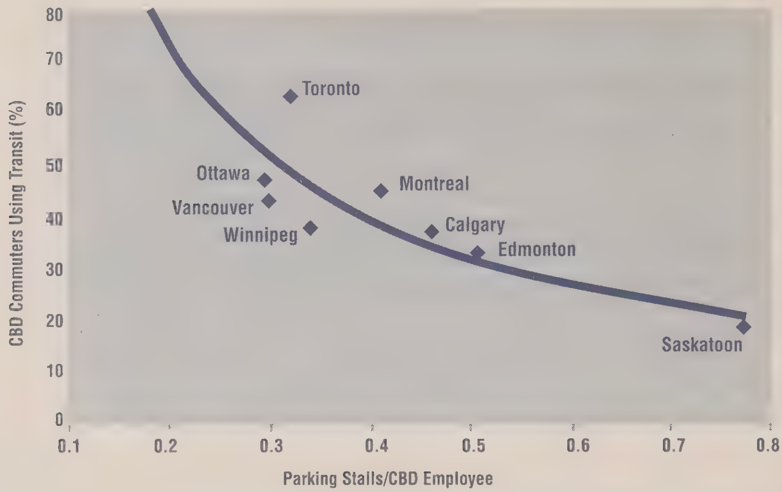
Some U.S. cities, including Cleveland and Minneapolis/St. Paul, have moved to address this issue by:

- permitting off-street surface parking on redevelopment sites where a parking deficiency exists;
- not renewing temporary off-street surface parking when a supply deficiency disappears; or
- taxing the site at highest and best use if the site remains undeveloped after two years.

A City of Calgary study demonstrates that there is a direct correlation between the amount of downtown parking available and public transit ridership.[39] Exhibit 3.12 shows the relationship between the percentage of commuters that use transit and the parking spaces per central business district employee.

Exhibit 3.12

Downtown Modal Split versus Parking Spaces per CBD Employee



Note:

CBD = central business district

Source: Recreated from Calgary GOPlan, *Calgary Downtown Parking and Transit Study Summary Report* (Calgary, 1994), p. 5, Fig. 3.

Elasticity of parking supply to vkt has not been widely studied. Based on a parking study of Boston, it has been established that the elasticity of vkt to parking supply could be about -0.16. As with parking supply, trips to downtown areas would likely be more elastic given the availability of alternative modes. Due to the high uncertainty of the elasticities of parking supply, for purposes of this Backgrounder we simply assume that the impacts of parking supply reductions would be similar to equivalent increases in parking price.

Road Pricing

Road pricing is used in many countries as a means of generating revenues to pay for the capital, operations and maintenance of road infrastructure, including bridges, tunnels and restricted-access highways. Only recently has congestion pricing been used more frequently to influence demand in peak and off-peak periods.

Road pricing can also be used as a means of making users pay for the full societal cost of road use, including "external" costs not currently reflected in market (monetary) terms, or as a means of contributing to specific vkt and CO_2 emissions reduction targets.

Historically, road tolls have been collected manually at toll booths. The latter have been sources of congestion and increased air pollution from vehicles idling in line-ups at road facility entry and exit points. Technological advances now make it possible to

use automated means for determining toll charges and for revenue collection. Highway 407 in the GTA and the new Highway 104 in Nova Scotia are recent examples. As technology advances it will become increasingly feasible and cost effective to use road pricing on a wider basis.

In the period to 2010, it is assumed that it would be technically feasible to introduce automated road or congestion pricing on all limited-access roads, as well as for major tunnels and bridges in the 13 CMAs.

Road pricing also has the potential of being a revenue source for dedicated funding of sustainable transportation alternatives such as public transit and other transportation demand management options (as will be discussed later) in the urban region where they are collected.

There are two primary categories of road pricing programs:

- Continuous facility pricing, with kilometre-based fees charged depending on vehicle class, for use of the facility at particular times of day. Variations can include peak-period pricing for all or selected routes in a system, or for all or selected lanes on a given highway.

- Area-wide pricing, with fees charged for entry to a congested area, such as a downtown business district, during peak hours. This option could be used to promote modal shifting away from single occupancy vehicle use in the designated area.

An area-wide implementation strategy using a downtown as a cordoned zone may have few environmental benefits at a regional level. Such a strategy could work in conflict with a strategy of more compact urban form by stimulating economic activity outside the congested core. If the core is large, many trips will be unaffected by the charge.

Area-wide road pricing might have merit in certain CMAs, such as the Montreal Urban Community, because of the unique constraints of bridge access to the Island of Montreal. It would not appear appropriate for a region such as the GTA, which is laid out on a grid with many access corridors for any part of the region, including the downtown core.

The major problem with continuous facility pricing is the potential for drivers to seek parallel, un-tolled routes such as arterials or local streets.

For purposes of this Backgrounder, vkt and CO_2 emissions reduction estimates have been made based on the following assumptions:

- congestion pricing is applied on all limited-access highways in the 13 CMAs; and

- congestion pricing is in place on all routes by 2010, with implementation taking place throughout the intervening period.

Vkt and emissions reduction estimates have been made for two simple pricing scenarios: \$0.10/km and \$0.20/km in the peak hours with a 50% reduction in the off-peak hours. As with fuel taxes, an elasticity of -0.2 has been used to estimate the impacts of road tolls on vkt. The results of the two scenarios are presented in Exhibit 3.13. These results should be considered broad estimates given the assumptions about the amount of vehicle-kilometres on limited-access highways in urban areas.

Exhibit 3.13

Impacts of Road Tolls

	Annual CO_2 (Kilotonnes)			Change from 2010 Baseline			Change from 1990		
	Passenger	Freight	Total	Passenger	Freight	Total	Passenger	Freight	Total
1990	39,589	8,390	47,979	—	—	—			
2010 baseline	45,581	12,887	58,468	—	—	—	15%	54%	22%
2010 New Scenarios									
$0.10 peak/$0.05 off-peak	44,317	12,694	57,010	-3%	-1%	-2%	12%	51%	19%
$0.20 peak/$0.10 off-peak	43,052	12,501	55,553	-6%	-3%	-5%	9%	49%	16%

Alternative Fuels

Alternative fuels have the potential to reduce GHG emissions from transportation. Currently, compressed natural gas and liquid propane are relatively widely available in the Canadian market. The technologies for these gaseous fuels are maturing, vehicle manufacturers offer factory-warranted alternative fuel vehicles, and significant investments in refuelling facilities have been made by fuel marketers. These lower carbon fuels can provide modest reductions in GHG emissions relative to gasoline. In recent years, ethanol as an additive to gasoline has entered the Canadian market. To date, this ethanol has been derived from corn. Research indicates that there may be greater potential for GHG emissions reductions with ethanol derived from cellulose.

Despite substantial continuing commitments in both the private and public sectors to the alternative fuel vehicle industry, market penetration has been limited. Alternative fuels currently represent about 1% of total light-duty vehicle fuel consumption. There are at present no major market conditions or pending government policy interventions that are likely to materially change market penetration of these fuels in the short term. However, market penetration is the key to unlocking their emissions reduction potential.

A major barrier to market penetration is the low price of gasoline. If a gasoline tax policy is adopted as part of Canada's climate change strategy for transportation, and if additional taxes are not imposed on the alternative fuels, then market penetration of the latter could be expected to rise, with benefits in CO_2 emissions reductions in the time frame of the Kyoto Protocol.

Summary of Impacts of Options to Reduce CO_2 Emissions from Road Vehicles

Exhibit 3.14 provides a summary of the estimated CO_2 emissions reduction impacts of seven of the policy measures discussed above. The impacts are shown for the case where each of the measures would be implemented individually. The impacts of implementing the measures in integrated packages are the focus of Chapter 4. On the basis of individual impacts, it would appear that fuel taxes, particularly when implemented on a North America-wide basis, would have significant potential for reducing emissions. An added benefit is that fuel taxes would generate significant revenues, as discussed on page 22. Feebates also show good potential for reducing emissions, although there is a significant level of uncertainty in the literature surrounding the potential impacts.

Exhibit 3.14

Summary of Estimated CO_2 Emissions Reduction Impacts of Policy Options *(top 13 CMAs in Canada)*

	Passenger	Freight	Total
Baseline Emissions (1990)	39,589	[illegible]	[illegible]
Business-as-Usual Emissions (2010)	[illegible]	[illegible]	[illegible]
% Change from 1990	[illegible]	[illegible]	[illegible]

Policy	Reduction in 2010 (MT)	% Change from 2010 Business-as-Usual	% Change from 1990 Level
Gasoline Tax[a]			
Scenario 1A: Gasoline tax ($0.03/litre annually, Canada only)	-5.3	-9%	11%
Scenario 2A: Gasoline tax ($0.054/litre annually, Canada only)[b]	-9.4	-16%	2%
Scenario 1B: Gasoline tax ($0.03/litre annually, North America-wide)	-8.0	-14%	5%
Scenario 2B: Gasoline tax ($0.036/litre annually, North America-wide)[b]	-9.5	-16%	2%
Diesel Tax			
Diesel tax ($0.03/litre annually, North America-wide)	-1.0	-2%	20%
CAFE and CAFC			
Canada only: 1% annual improvement taking effect in 2005 (new vehicles only)	-0.7	-1.2%	20%
North America-wide: 2% annual improvement taking effect in 2005 (new vehicles only)	-1.2	-2.1%	19%
Feebates[b]			
Feebates implemented in Canada only			
C$350/litre/100 km	-0.7	-1%	20%
C$700/litre/100 km	-1.1	-2%	20%
C$1,400/litre/100 km	-2.2	-4%	17%
C$2,800/litre/100 km	-4.0	-7%	14%
Feebates implemented North America-wide			
C$350/litre/100 km	-2.2	-4%	17%
C$700/litre/100 km	-3.1	-5%	15%
C$1,400/litre/100 km	-4.4	-8%	13%
C$2,800/litre/100 km	-6.2	-11%	9%
Vehicle Maintenance and Inspection Programs			
Impacts assuming 1% reduction in fleet emissions	-0.6	-1%	21%
Impacts assuming 3% reduction in fleet emissions	-1.8	-3%	18%
Parking Pricing			
Impacts of 5% annual parking price increase	-4.6	-8%	12%
Road Pricing			
$0.10 peak/$0.05 off-peak	-1.5	-2%	19%
$0.20 peak/$0.10 off-peak	-2.9	-5%	16%

Notes:

CAFE/CAFC = Corporate Average Fuel Efficiency/Consumption

[a] Estimated emission reductions from distance-based insurance and vehicle registration fees are assumed to be similar to those of gasoline taxes and feebates respectively.

[b] These are the price increases that would be required to achieve a 6% reduction in CO_2 emissions from 1990 levels by 2010 for gasoline vehicles only.

It is possible that technological developments over the period being analyzed could improve energy efficiency and therefore significantly reduce CO_2 emissions. Some technological improvements, foreseen by Natural Resources Canada in a business-as-usual scenario, have been included in the baseline forecasts.

The changes in vehicle technology described in this report are those that can plausibly be introduced early enough to have a significant impact in Canada within this report's time frame (i.e., from approximately 2000 to 2010). However, more advanced technologies for both conventional and alternative fuel vehicles are under development. Promising technologies include:

- fuel cells using natural gas, alcohol or hydrogen fuel to produce on-board electricity for electric drives; and
- various hybrid gasoline and electric vehicles, including one with an internal combustion engine that both charges an electric energy storage system and powers the mechanical drive system.

A major limiting factor in taking advantage of these opportunities is that it takes more than a decade for new technology, once it becomes commercially viable, to replace existing fleets.[40]

The Toyota Prius is one example of a technology that appears promising in the short term. This hybrid vehicle has been available in Japan since December 1997. The Prius delivers twice the fuel economy of a comparable conventional technology vehicle in low speed, stop and start conditions. At a speed of 77 km/hour, the Prius is 1.2 times more efficient than conventional automobile technology.[41] Toyota recently announced that it would be selling the Prius in North America and Europe by the year 2000. Consumer acceptance remains in question, however, since Toyota's actual unit production costs are estimated at $60,000 at current production levels.[42]

Various government-funded R&D projects are under way in Canada that may hasten the commercial use of technologies that were not incorporated into the analysis of this report.

In 1981, for example, Natural Resources Canada launched its Alternative Transportation Fuel Market Development Initiative. The purpose is to promote the development and use of alternative fuels such as propane, natural gas, methanol, ethanol, electricity and hydrogen. Natural Resources Canada works with the alternative transportation fuel industry and major vehicle manufacturers in Canada to promote alternative transportation fuels, principally to fleet operators in both public and private sectors, and to increase public awareness of alternative transportation fuels.

For its part, Transport Canada has an R&D program containing a variety of objectives related to sustainable transportation. They include:

- promoting the design and deployment of buses that are safer, more energy efficient and environmentally friendly, and more productive and comfortable;

- assessing the potential benefits of electric vehicle technologies, that is, their safety, efficiency and environmental effects;
- investigating the use of alternative fuels; and
- investigating emerging technologies and taking advantage of national and international R&D developments.

Studies in progress at Transport Canada include one that is evaluating sustainable transportation technologies in order to develop a strategy for fostering their development. Another study by the department is assessing the safety of natural gas and hydrogen vehicle cylinders.

In addition to government-funded R&D, other initiatives such as procurement policies, legislation and partnerships with the private sector can promote the dissemination of more sustainable motor vehicle technology. Examples include:

- The Partnership for a New Generation of Vehicles (PNGV), a collaboration between the U.S. government and the Big Three vehicle manufacturers. The goal of the PNGV is to develop an automobile that achieves 80 mpg and that meets consumer expectations for performance, functionality, safety and economy. The total annual budget is about US$300 million (80% provided by the U.S. government).
- California's Low Emissions Vehicle Regulations mandate emission criteria for a certain proportion of new vehicles available in the California consumer market. For example, the regulations state that by the year 2003, 75% of the new vehicle market must be made up of low emissions vehicles, 15% by ultra-low emissions vehicles (at present, natural gas vehicles can achieve these requirements), and 10% by zero emissions vehicles (at present, only electric vehicles meet these requirements). The U.S. *Clean Air Act Amendments* of 1990 allow other states, such as Maine and New York, to opt into this program.
- The Canadian and the U.S. federal governments, along with several state governments, have mandated that a certain proportion of their light-duty fleet purchases must include alternative fuel vehicles. The Canadian *Alternative Fuels Act* (Bill F-7) was initiated by the Transportation Committee of the Senate. The essence of the act is that an increasing proportion of the federal government's vehicle fleet (approximately 25,000 vehicles) should operate on alternative fuels (e.g., ethanol, methanol, propane, natural gas, hydrogen, electricity), thus accelerating the use of alternative fuels for motor vehicles. By 2004, 75% of all motor vehicles operated by federal bodies and Crown corporations are to operate on alternative fuels.

Expanding Modal Choice

A practical CO_2 emissions reduction strategy must also expand the availability of attractive alternatives to road vehicles, if consumers and businesses are to be motivated by the above policies to constrain their use of high-emitting vehicles. Policy options aimed at encouraging expanded choice for people to access personal and commercial activities are discussed in the remainder of this section under the headings of Enhanced Public Transit, Land Use/Urban Design, and Other Transportation Demand Management Policy Options.

Quantitative estimates of CO_2 emissions reductions from these categories of policy options have not been attempted in this report for two primary reasons:

- Each of the three categories is composed of a large number of measures for which individual estimates would be impractical.
- It was the judgment of the consulting team that demand management, transit and land use policies can only be effective in meeting the very challenging Kyoto target if applied in support of the more direct policies for reducing road vehicle use. The issue of synergy among policy options is discussed more extensively in the next section.

Enhanced Public Transit

Many studies in recent years have recommended a wide range of measures for reversing the continuing decline in the modal share of public transit relative to personal road vehicle use. When operated close to design capacity, public transit systems, both bus and rail, show major energy efficiency advantages and lower emissions of air pollutants including CO_2 emissions. However, transit systems operated at low load factors produce greater emissions per passenger-kilometre than road vehicles.[43]

Modal shifting from personal road vehicles to public transit will only result in CO_2 emissions reductions where population densities support strong transit systems. At currently reported load factors for public transit in Canada, Transport Canada has estimated that a doubling of transit ridership would divert 12.5 billion passenger-kilometres from personal vehicles, reduce fuel use by 1.74% and reduce GHG emissions by 1.55 MT.[44] These figures should be used as broad indicators only, since the reporting of passenger-kilometres for transit usage in Canada does not separate bus and rail transit figures. The largest transit property in Canada, the Toronto Transit Commission, does not report passenger-kilometre data.

Data collected by the Canadian Urban Transit Association show that the average number of persons per transit vehicle in Canadian cities is about 17.[45] Assuming the average occupancy of cars to be 1.5 persons and the average light-duty fuel economy rating to be about 10 litres/100 km, the literature suggests that emissions per passenger-kilometre for transit would be somewhat lower than those for personal vehicles.[46] This is a very crude estimate of the relative emissions of transit and cars. There is a need for a much more complete comparative analysis of actual per passenger-kilometre emissions of these modes in Canadian cities.

The potential for increasing overall average load factors in Canadian transit is unknown. A key factor in achieving such gains would be long-term shifts toward more compact urban development in all cities, including the municipalities outside the core cities in the Vancouver, Toronto and Montreal urban regions.

By comparison, in the United States cars now use less energy per passenger-kilometre than urban buses.[47] This is partly because the fuel efficiency of cars has advanced more rapidly than that of buses since the 1970s. However, the major cause in this historic reversal is the decline in the average occupancy of transit buses in the United States.

It is possible that, through a combination of policy measures and technology advances, the fuel efficiencies of passenger vehicles on the road could double over the next 20 years. Comparable improvement in fuel consumption per passenger-kilometre in transit will be required if transit is to maintain its energy efficiency competitiveness. Improvements in buses can come from both technology advances and from increasing load factors. The former can be encouraged through regulation and standards, the latter through transit service innovations and investments and policies that discourage personal vehicle use.

Increasing the modal share of public transit will require two fundamental changes in policy direction by governments:

- policies that directly reduce single occupancy vehicle demand; and
- policies that increase the availability and attractiveness of public transit as an alternative to road vehicle use.

One recent report, *Trans-Action 98*,[48] summarizes the priority measures that transportation professionals consider to be the "most achievable, politically acceptable and have the highest potential to bring about modal shift to transit." All of the proposed actions, if implemented, could be contributing to CO_2 emissions reductions in the period up to 2010.

The *Trans-Action 98* report is the outcome of a transit summit held in Toronto in December 1997, as well as a review of the extensive recent national literature on the subject. Seven of the top 10 recommendations in this action plan (presented in summary form as Exhibit 3.15) are not specific to the GTA. They could facilitate a modal shift to transit in any Canadian CMA. The remaining three recommendations could be readily adapted to the institutional arrangements existing in other cities and city-regions. In some jurisdictions, such as British Columbia and Quebec, some of the recommendations are already being implemented. But there is no jurisdiction in Canada where the majority of these proposals have been adopted.

Exhibit 3.15

Summary List of Actions from Trans-Action 98 — An Action Plan for a Modal Shift to Transit in the Greater Toronto Area

Federal Government Action

1 **Tax Treatment of Transit Passes** — Make employer-provided transit passes a non-taxable employee benefit to encourage increased use of transit as an option for getting to work (in Canada currently only 10 percent of employees use transit to get to work, whereas 80 percent use a car, truck, or van.

Joint Federal/Provincial/Municipal Government Action

2 **Overall Taxation and Subsidy Strategies for Transit and Transportation Funding and Modal Choice Incentives** — Develop an overall taxation and user-pay strategy, and evaluate and re-align subsidy programs, to support and encourage transit.

Provincial Government Action

3 **Greater Toronto Services Board (GTSB)** — Establish the GTSB with the mandate and authority to administer cross-boundary transit service integration, overall Greater Toronto Area transit planning, GTA-wide fare policies and municipal funding levels, including GO Transit. An overall Modal Shift Action Plan should also be prepared on a GTA-wide basis, and the GTSB can play an instrumental role in developing this plan. *[Ed. Note: Moves in this direction have already been made in British Columbia with respect to the Greater Vancouver Regional District and in Quebec with the new Metropolitan Transportation Agency for the Montreal region.]*

4 **Access to Alternative Funding Sources** — Amend the Municipal Act to allow municipalities to use alternatives to property tax to fund transit, such as fuel taxes, road pricing revenues (tolls), vehicle registrations or sales tax, etc. *[Ed. Note: Action in this area is being taken by the Government of British Columbia.]*

Provincial and Municipal Government Action

5 **Transit Supportive Land Use Planning Guidelines as Policy** — The Provincial Government should amend the planning process to provide means of ensuring that municipal and regional plans are consistent with transit-supportive planning principles. Municipalities should incorporate specific measures included in the Ontario Ministry of Transportation (MTO)/Ontario Ministry of Municipal Affairs and Housing (MMAH) Transit Supportive Land use Guidelines into Official Plans and municipal policies on land use planning and development.

Municipal Government Action

6 **Transportation Demand Management Plans and Strategies** — Each municipality should develop and adopt an overall Transportation Demand Management plan and specific strategies to meet the demand management objectives. These should include specific targets and timetables for modal shifts as well as strategies and actions to achieve targets, especially in the areas of transit improvements, managing the supply and pricing of parking and better managing the supply of road capacity.

Transit System Action

7 **Modal Shift Action Plans** — Each transit system should adopt its own Action Plan (e.g., percent modal shift targets over a certain time frame) for a modal shift to transit and make it the basis for transit service plans and annual transit budgets. An overall Modal Shift Action Plan should be prepared on a GTA-wide basis, and transit systems can play an instrumental role in developing this plan.

Corporate Action

8 **Employee Transit Programs** — Implement employer-based education, transit coordination and transit programs for employees. (The authors of *Trans-Action 98* acknowledge the such actions can be incorporated into broader employee transportation plans that address other measures such as cycling, walking, van pooling and ridesharing.)

Advocacy Organization Action

9 **Public Education Programs** — Advocacy organizations should take the lead in an ongoing effort to better educate the public on the costs and dangers of increased private vehicle use and the benefits of a modal shift to transit, including getting this type of material into school curricula. *[Ed. Note: The Centre for Sustainable Transportation has adopted similar recommendations made by the NRTEE and has begun developing programs targeted at primary, secondary and post-secondary levels.]*

Actions for Pollution Probe and/or CUTA

10 **Building Support and Getting Commitment** — Make presentations on the Transit Action Plan and build broad based coalitions to develop stakeholder support for specific actions noted in this Action Plan.

Source: Pollution Probe, Canadian Urban Transit Association, Toronto Transit Commission, *Trans-Action 98* (Toronto, May 1998). This report is the outcome of a transit summit in December 1997.

Land Use/Urban Design

"Cities were invented to facilitate exchange of information, friendship, material goods, culture, knowledge, insight, skills, and also the exchange of emotional, psychological, and spiritual support. ... That is why we build cites. Cities are concentrations of people, and structures that enable mutual exchange to take place while minimising the travel needed. ... But even though the city's basic function is to maximise access to exchange opportunities while minimising the need to travel, a certain amount of travel or movement is still necessary within the city to facilitate mutual exchange. Hence the need for transport systems as a means to an end, to facilitate exchange."[49]

Many observers have suggested that the current phenomenon of urban sprawl had its origins in the Industrial Revolution when cities became crowded, filthy and disease-ridden and focused on industrial output. The concept of suburban garden cities was born in the Victorian age as a means for the wealthy to escape the then despised city. The concept has been very widely embraced in the 20th century, particularly in North America, with the growing wealth of the middle class and mobility provided by the automobile. Societies moved away from the sometimes chaotic, compact, mixed use form of urban development to the current model of separation of the activities of life, with the vast majority of face-to-face connections being made through automobile travel.

The mobility provided by road transportation has become so pervasive that the lines are blurred for many between its role as a means for human exchange and as an end in itself.

There is now evidence that reurbanization is going on in many parts of the world, as polluting industries have been cleaned up or moved away from heavily built-up areas. In many respects, cities, at least in the developed world, are being revitalized as places of human exchange. But the problem of transportation remains.

Research on urban regions around the world shows that "car use does not necessarily increase with increasing wealth but tends to fall in the most wealthy cities. Where wealth is accompanied by land use and transport policies which do not facilitate car travel, car use will be lower."[50]

Urban population density has been shown to relate strongly to road vehicle use. The data from worldwide research confirm that cities with densities below 30 persons/hectare (ha) have a high dependence on the automobile for most urban travel.[51] Population densities in Canadian cities average 25 to 30 persons/ha, higher than in U.S. cities, but lower than in European cities. The City of Toronto has a population density of 41 persons/ha, comparable to European cities. Its transit system recovers 80% of operating expenses from the fare box. Population density in the urbanized areas of the other municipalities in the GTA averages 26 persons/ha, and the modal shares of transit are dramatically lower. Transit systems in these suburban communities are more heavily subsidized than the Toronto Transit Commission.

It can be concluded that, compared with lower density cities, transit in cities with densities above 30 persons/ha:

- can achieve higher modal share relative to personal vehicles;
- is more cost effective and requires less subsidy per passenger-kilometre; and
- can generate lower CO_2 emissions.

It has also been shown that auto-dependent urban sprawl is expensive in terms of the capital and maintenance costs of public infrastructure such as water mains, sewers and other utilities, as well as roads. For example, it has been estimated that $1 billion annually could be saved by constraining urban sprawl in the GTA, reducing the financial burden on municipalities and increasing the region's competitiveness.[52]

The Transportation Association of Canada and other observers have pointed out that current shortages of public funds to invest in expanded infrastructure, including transportation, provide governments with the motivation to consider more cost effective urban settlement patterns. Governments are beginning to use least cost evaluation techniques that examine transportation modal alternatives and incorporate the external costs of congestion, accidents, health and environmental impacts in making transportation investment decisions.

Many measures have been proposed for intensifying settlement patterns in Canada's urban regions. In addition to reducing CO_2 emissions by reducing the need for motor travel, these measures can be expected to bring many other social, economic and environmental benefits.

Some of the land use policy options that can make transportation more sustainable over the long term include:

- Developing provincial policy guidelines to ensure that municipalities develop and implement transit-supportive and transportation demand management-supportive land use and transportation policies in official plans. Key policies are those that enable more compact, mixed use urban form, residential and commercial intensification, including redevelopment of brownfield (abandoned industrial) sites and development around major transportation hubs.

- Restricting vehicle access in urban cores, as is increasingly practised in European cities. Experience has shown that, properly designed and implemented, such zones stimulate rather than constrain economic, social and cultural activity.

- Improving cycling and pedestrian environment and facilities, including giving cycling and walking priority over personal vehicles.

- Encouraging increased use of telework, including telecommuting, teleconferencing and distance education. More research is required to identify the extent to which such advanced communications techniques can reduce motor travel. This is an extremely complex subject. One suggestion for study would be the impacts of teleconferencing on the per-employee travel of international consulting firms. Many such firms now routinely use teleconferencing as a mature business tool, and have the administrative capacity and corporate culture to support such research.

- Creating public/private collaborations to investigate new, more efficient options for goods movement within cities, including freight transfer facility locations and new intracity freight consolidation service innovations.
- Building on the outcome of the July 1998 Moving the Economy Conference in Toronto (organized by the City of Toronto and Transportation Options), which showcased success stories and ideas about the economic benefits being achieved around the world in redesigning cities and transportation systems for sustainability. An economic action plan/agenda is expected to be developed in the coming months, which could be used as a model by any city for economic development based on sustainable transportation initiatives. The interdependence of land use/urban design and transportation was strongly reinforced during this important international event.

Other Transportation Demand Management Policy Options

Transportation demand management (TDM) is a term used to categorize a very broad range of policies and actions for reducing the use of road vehicles and encouraging shifts to more sustainable modes of transportation. Many of the options discussed above are included as TDM measures in the literature. This section examines a range of other TDM measures that indirectly affect road use by encouraging the use of other means to access activities. The following are selected examples of other TDM measures drawn from a number of sources.[53]

Intermodal Transfer Nodes — Passenger

The economic, social and environmental benefits of integrating and facilitating intermodal transfer for both passenger and freight are well known. Research shows that intermodal facilities for passengers can be important focal points for urban revitalization and intensification. There are notable examples in Canada including:

- Integration of SeaBus, Skytrain, Vancouver Transit and commuter rail in downtown Vancouver.
- Union Station in Toronto, currently the centre of intense study for redevelopment for expanded commuter rail and bus (GO Transit), Via Rail and a downtown bus terminal, integrated with the new Air Canada Centre sports complex, the SkyDome, the expanded Toronto Convention Centre and new retail and tourism development. More than 100,000 people pass through this facility each weekday. GO Transit forecasts a near doubling of passenger volumes through Union Station by 2021. To handle this traffic, extensive improvements to the facility, estimated to cost in the range of $100 million, will be required for GO Transit alone.[54]
- Place Bonaventure in Montreal, which integrates hotel and retail facilities with Via Rail, commuter rail and bus transit services.

Many other smaller passenger transportation nodes in Canadian CMAs provide essential links among municipalities within each urban region and intermodal links within the municipalities.

Development of transfer nodes is vital to the emergence of sustainable urban transportation in Canada. By making intermodal transfer easier, transfer nodes increase the availability of attractive transportation options for all citizens and encourage use of more energy efficient modes. They also create expanded opportunities for increased cultural, social and commercial exchange.

Senior levels of government have important roles to play in helping cities and business to realize the substantial economic, social and environmental benefits available from continued development of intermodal transfer nodes in Canadian cities. A critical priority for the federal and provincial governments should be to develop new and robust mechanisms for financing the (re)development of transportation transfer node facilities in the context of a broader policy shift toward the financing of sustainable transportation.

Managing Road Supply, Including High Occupancy Vehicle Lanes, and Sharing of Existing Road Space with Other Users

The pace and modal/geographic balance of added capacity and related enhancements to the road, transit, pedestrian and cycling networks can have an influence on transportation behaviour as well as transportation system performance and emissions. Some options for managing road supply and sharing of road space include:

- Stabilizing road supply, that is, the numbers of kilometres, roads and lanes available in a geographic area.
- Providing restricted access lanes for high occupancy vehicles (HOVs), alternative fuel vehicles, zero-emission vehicles or car-sharing club vehicles. HOV lanes, reserved bus lanes or busways will be essential for high-quality express bus services to serve a growing market between and within municipal centres outside the downtown core of each city-region. Such services are contemplated in the regional planning strategies of the Greater Vancouver Regional District, the GTA (GO Transit) and the Montreal Urban Community Transit Commission. Experience with HOV lanes in Canada has been mixed for several reasons. Compliance with HOV regulations is a known problem. In addition, HOV lanes have tended to be established on individual roads, and not as systems that would allow integration of bus services over a grid of intersecting bus routes for increased convenience to transit riders.
- With respect to freight transport, upgrading and expanding the national highway system, including portions within urban areas. Trucking and shipping organizations have long advocated such increased highway investment by the federal and provincial governments. In certain corridors, however, it may be cost effective for both the public and private sectors to consider state-of-the-art intermodal rail/truck services as an alternative to expanded highway capacity. The rail and trucking industries, along with shippers and federal and provincial governments, should also examine

least cost options for intercity freight movement. The first corridor for such study and decision making should be the Windsor-Quebec corridor, the most heavily travelled freight corridor in the country. (See Modal Shifting and Consolidation of Freight Movement, page 56.)

Traffic Calming and Street Reclaiming

The sustainable neighbourhood and the sustainable transportation system require a different view of urban settlement from that used in the past. "Instead of seeing themselves as 'mechanics' planners would see themselves as 'doctors'. ... In listening to the heartbeat of neighbourhoods, these 'doctors' ... would be searching to understand what promotes life and what takes it away. They would become preoccupied with entirely different questions (than traditional planners). What makes this neighbourhood tick? Why is there a sense of togetherness in this street and not this one? Why does this park work as a people place and not this one? Why is crime high in this neighbourhood and not this one? Is there a connection between traffic flow and the quality of community life?"[55]

"Traffic calming involves fundamental rethinking of metropolitan planning and organization, and a renewed emphasis upon quality rather than quantity of life."[56]

The objective in a new approach to land use planning should be to maximize the opportunities for human exchange at minimum social cost. David Engwicht suggests the following ways to optimize exchange efficiency:[57]

- Bring the destinations to the people.
- Increase the density of housing, job and (commercial and social) exchange opportunities.
- Creatively mix housing, job and exchange opportunities.
- Charge the true costs of exchange opportunities.
- Promote exchange-friendly modes, such as walking, cycling and transit, that facilitate human exchange.
- Convert planned exchanges into home-based or spontaneous exchanges.
- Encourage diversity and expression of diversity.
- Build the "Commons."
- Give people and neighbourhoods greater control over decision making.
- Make those usually considered least into those considered most.

Location Efficient Mortgages

A test of the location efficient mortgages (LEM) concept is scheduled in Chicago in the fall of 1998. The program is sponsored by the Center for Neighborhood Technology of Chicago, the Natural Resources Defense Council of California and the Surface Transportation Policy Project of Washington, D.C. It provides for "stretch" in allowable income-to-expense ratios in mortgage applications for households. Eligibility

is based on the number of vehicles owned and distances driven, for homes purchased in designated areas served by public transport. It is targeted at low and middle income families, giving recognition to the cost savings from lower automobile ownership and use.

Car-Sharing Clubs

Conceptually, car sharing is time sharing of automobiles. It is a way to have access to a car when needed without the full burden of ownership, maintenance and insurance. Members pay a small monthly fee and a low hourly and kilometre charge based on vehicle use. Studies of car-sharing programs in Europe indicate that members, including those who previously did not own a car, reduce their annual vehicle usage (measured in vkt) by 30% after one year of participation.

A recent Canadian survey of prospective car-sharing members suggests that most (50 of 70) do not own a car but drive on average about 6,700 km per year in borrowed or rented cars.[58] Assuming that, on average, cars driven before car sharing were larger, older and less fuel efficient than the newer subcompacts of a car-sharing fleet, per member reduction of CO_2 emissions from car sharing has been estimated to be about 50%.[59]

Car sharing complements conventional car rental. The latter is more economical to the consumer for trips of greater length or duration. In both cases, the consumer is directly confronted with the full variable costs of the distance driven and motivated to reduce vehicle kilometres travelled.

Switzerland is now served by car-sharing clubs in 600 locations throughout the country, serving 20,000 clients with about 1,000 cars. Car-sharing clubs/businesses have been established in Quebec City (Auto Com), Montreal (CommunAuto), Vancouver (Co-operative Auto Network [CAN]) and Victoria (Victoria Car Share Co-op). The launch of a new club in Toronto is reported to be imminent.

Governments can support this fledgling industry in a number of ways:

- They can fund sustainable transportation incubators. Car-sharing clubs are small entrepreneurial businesses focusing on communities or neighbourhoods. They need financial and management help in the start-up phase. The Quebec government has provided grants for the start-up of car-sharing clubs in that province. Environment Canada has provided money for a pilot program in Vancouver. In Toronto, efforts are under way within the community to establish a sustainable transportation incubator.

- Municipal governments can support car sharing by providing car-share vehicles with permits to park anywhere that permit parking is in effect. This has been done in Quebec City.

- Car sharing can support public transit use if appropriate incentives are in place. Discounts by transit authorities on monthly transit passes for car-sharing members are one possible incentive.

Modal Shifting and Consolidation of Freight Movement

Measures that can reduce market distortions in freight movements originating or ending in urban centres include property tax exemptions for railway rights-of-way, increased capital depreciation for railways, and protection of railway rights-of-way.

Based on past and expected future trends, diesel fuel consumption in trucking is growing and will grow faster than gasoline consumption. A major, though unknown, percentage of fuel use is for intercity trucking in corridors where intermodal services have the potential to be competitive and to increase the rail modal share.

Intergovernmental cooperation in support of rail/truck intermodal/bi-modal infrastructure planning is essential to the expansion of commercially viable truck/rail services. For the larger cities in Canada, governments and private sector carriers and shippers need to carefully examine, together, how energy and economic efficiency of freight transport, in appropriate corridors, can be improved through expansion of intermodal/bi-modal services.

Cost effective intermodal transfer of freight is also important to the economic vitality of urban regions and in facilitating CO_2 emissions reduction from intercity freight movement. The maturing of commercially viable intermodal rail/truck technologies, such as Iron Highway (CP Rail/St. Lawrence and Hudson Railway) and Eco-Rail (CN), presents new opportunities for expanding intermodal market share in high-density corridors. All levels of government have key roles to play, in partnership with rail and trucking industries, in planning and developing the necessary intermodal facilities in major urban centres.

Within CMAs, local distribution of goods is a major contributor to congestion and pollution. New concepts of local freight consolidation are emerging in Europe that should be examined for application in Canadian cities.

Walking School Buses

Based on a neighbourhood initiative originally started in Australia and now in Toronto as well, residents organize to walk groups of children to school instead of using automobiles. This healthy, cost effective idea, originally conceived to provide safety and security for children, takes cars off the streets and reduces emissions of air pollutants. It also has a positive socializing impact on both the children and the adults in a neighbourhood. The concept is spreading rapidly across Canada and internationally. The Walking School Bus requires limited full-time staffing to promote and maintain program momentum, and to provide advice and support to neighbourhood volunteers who perform the service.

4

Development and Assessment of Integrated Packages of Options

Development and Emissions Impacts of Integrated Packages

There is near consensus among government, private sector and non-governmental organizations that emissions reductions from transportation to meet the Kyoto target cannot practically be achieved by:

- *Any one level of government* — no level or department of government has sufficient policy levers in its jurisdiction.
- *Governments acting alone* — meeting the Kyoto targets will require cooperation among all levels of government, industry and the public.
- *Any single policy measure* — no single measure is likely to be sufficient. All effective measures have limitations. Conversely, many policy options have the potential to work synergistically to reinforce one another and to offset undesired economic, social and environmental side effects of other options.
- *Technology alone* — extensive international research leads to the conclusion that advances in technology are unlikely to be sufficient to overcome the negative emissions impacts of projected growth in energy intensive modes of transport. There is broad agreement that, in addition to improvements in technology, changes in societal behaviour will be needed to reduce the per capita demand for transport. Recent research by Environment Canada as part of a broader study by the Organization for Economic Cooperation and Development suggests that practical ratio of technology changes to policies that affect transportation demand in Canada may be in the range of 50/50.[60] This was based on assumptions that new technology such as fuel cells could be introduced over the next 30 years or so and come into widespread use.

An effective strategy to meet the Kyoto targets will therefore require integrated packages of policy options that involve all three levels of government and have broad business and public support. The question is "What should such integrated packages contain?"

For this Backgrounder, three possible packages are considered with various options within each package depending on whether it is implemented on a Canada-only or North America-wide basis. In the main, North America-wide measures that encourage changes in technology are more effective because manufacturers have much more incentive to invest in technology for the larger North American market. The components of the three options are shown in Exhibit 4.1. A discussion of each of the packages is provided in the following sections.

Exhibit 4.1

Summary of Integrated Packages

Individual Initiatives	Combinations					
	Package A		Package B		Package C	
	Road Vehicles — Basic		**Road Vehicles — Alternative**		**Comprehensive Package**	
	Canada only	North America-wide	Canada only	North America-wide	Canada only	North America-wide
1 Fuel taxes (gasoline)	✔	✔			✔	✔
Fuel taxes (diesel)		✔				✔
2 CAFE/CAFC	✔	✔			✔	✔
3 Feebates	✔	✔			✔	✔
4 Vehicle I&M			✔	✔	✔	✔
5 Vehicle charges and taxes			✔	✔		
6 Parking pricing/supply			✔	✔	✔	✔
7 Road pricing			✔	✔	✔	✔
8 Alternative fuels			✔	✔		
9 TDM					✔	✔
10 Enhanced transit					✔	✔
11 Land use/urban design					✔	✔

Notes:

CAFE/CAFC = Corporate Average Fuel Efficiency/Consumption
I&M = inspection and maintenance
TDM = transportation demand management

Package A: *Road Vehicles — Basic*

Light-duty gasoline vehicles produce 82% of carbon dioxide (CO_2) emissions from urban transportation. The three policies included in this package are targeted directly at reducing light-duty vehicle emissions. Each measure can contribute to improving total fleet fuel efficiency.

The federal government has jurisdiction to implement policy change for each option and could take unilateral action on this package. Cooperation with the provinces could produce an even stronger package. The measures included in Package A are the strongest measures available to the federal government (except for fuel rationing or emissions trading, which were outside the scope of this study). Package A is examined for two different cases, with and without harmonization with the United States.

The policy synergies or interactions among the options in this package are as follows:

- The package collectively influences vehicle-kilometres travelled (vkt), vehicle purchase choice and therefore new vehicle fleet mix (vehicle size and fuel economy) and manufacturers' product offerings, including average vehicle weight and technology content (more so for the North America-wide option). All of these variables can affect new vehicle and "fleet on the road" fuel consumption and CO_2 emissions.

- The gasoline tax is the strongest measure for reducing CO_2 emissions because it is the measure that directly or indirectly influences the broadest range of short- and long-term decisions by consumers, businesses and governments. It is considered to be among the most cost effective measures available. Gasoline pricing also has a significant impact on vkt, affecting consumer behaviour over both the short and the long term. Over the long term, it could have similar impact on the technology decisions of manufacturers, particularly if fuel tax policy were to be used across North America. It could also affect vehicle purchase choice over the long term.

- Increasing gasoline price through taxation counters the demonstrated weaknesses in CAFE/CAFC standards including:

  - the take-back effect, which results in increases in vkt of up to 30% of the gain from the standard, as a result of lower operating costs from improved fuel economy;

  - technology uptake by manufacturers. CAFE/CAFC has been shown to be relatively weak in motivating car makers to incorporate fuel efficiency technologies into vehicles. Instead they have tended to focus on vehicle weight and marketing (pricing) strategies to achieve CAFE targets. Fuel taxes provide additional market incentive for technology uptake; and

  - the fact that CAFE/CAFC provides no incentive to reduce vkt or to shift to more energy efficient modes.

- Feebates can have the most direct impact on consumers' vehicle purchase decisions and reinforce the weaker effects of both the gasoline tax and CAFE/CAFC in this regard. Addition of the feebate could encourage the shift to smaller vehicles.

- CAFE/CAFC directly affects manufacturers' marketing decisions as they adjust sales approaches to meet their targets.

- Gasoline taxes are preferred by North American vehicle manufacturers over CAFE/CAFC and feebates, because the latter tend to favour Asian manufacturers whose product offerings on average are smaller and more fuel efficient. A policy package that includes gasoline taxes is likely to be more acceptable to car manufacturers since it tends to level the competitive playing field.

The assumed levels of intensity of the measures for Package A were as follows:

- a gasoline tax increase of 3 cents/litre/year starting in the year 2000;
- a diesel fuel tax increase of 3 cents/litre/year starting in the year 2000 (North America-wide package);
- CAFE/CAFC standards announced in 2002 and effective starting in 2005; and
- a feebate program introduced in 2005 (assuming a feebate rate of $1,400/litre/100 kilometres).

There are a number of complex relationships between the individual measures of Package A that are difficult to quantify. To some extent, the measures in Package A enhance each other; however, there is also some overlap between the measures (e.g., CAFE and feebates both affect vehicle technology). For the purpose of this study, it was assumed that the impacts of the combined package would be similar to the sum of the individual impacts. One exception is that the take-back effect for CAFE standards (assumed to be one-third) would likely be reduced or eliminated as a result of higher fuel prices. The projected impacts of CAFE standards were therefore adjusted accordingly.

Exhibit 4.2 provides a broad indication of the combined impact of the three measures proposed as part of Package A. Based on the assumptions outlined above, the net impact of the three measures, if implemented on a Canada-only basis, would be a CO_2 emissions reduction from the 2010 baseline of 16% for passenger vehicles and 5% for freight vehicles (gasoline only). In the Canada-only case, it was assumed that diesel fuel taxes would not be increased for reasons of international competitiveness. If implemented on a North America-wide basis, the impacts would be a CO_2 emissions reduction of 26% from the 2010 baseline for passenger transportation and a 14% reduction from the baseline for freight vehicles. In terms of meeting the Kyoto targets, the North America-wide scenario would exceed a 6% reduction from 1990 levels by 2010 for passenger vehicles and overall. If implemented on a Canada-only basis, the impacts of fuel prices (on vehicle technology), CAFC and feebates are much reduced. With the level of fuel price increases assumed, the Kyoto target would not be met for the Canada-only case.

Exhibit 4.2

Impacts of Integrated Package A

	Annual CO_2 (Kilotonnes)			Change from 2010 Baseline			Change from 1990		
	Passenger	Freight	Total	Passenger	Freight	Total	Passenger	Freight	Total
1990	39,589	8,390	47,979	—	—	—			
2010 baseline	45,581	12,887	58,468	—	—	—	15%	54%	22%
2010 New Scenarios									
Canada only	38,143	12,287	50,430	-16%	-5%	-14%	-4%	46%	5%
North America-wide	33,526	11,043	44,569	-26%	-14%	-24%	-15%	32%	-7%

Package B: *Road Vehicles — Alternative*

This package is a similar to Package A in that it targets road vehicles; however, more measures are combined to form the package. It also directly targets road vehicle technologies and driver behaviour. Other market pricing measures such as parking policies, road pricing and vehicle charges are included that could either complement or be used in place of gasoline taxes. Mandatory road vehicle inspection and maintenance (I&M) programs are included in this package to address the issue of lifetime vehicle emissions.

Package B comprises measures that could be applied under provincial and/or municipal jurisdiction. The options, within limits, could be applied independently of the policy direction taken by the United States; however, in the case of vehicle charges (assumed to be similar in impact to fuel taxes), the impacts would be enhanced if implemented on a North America-wide basis.

For the purpose of illustrating the impacts of the alternative road vehicle package, the following levels of intensity were assumed:

- vehicle I&M, with full implementation by the year 2000;
- vehicle charges (annual registration fees), with a fleet fuel economy impact equivalent to feebates;
- vkt charges and distance-based insurance, with a demand impact similar to fuel taxes;
- parking pricing (5% annual increase from 2000 to 2010); and
- road pricing ($0.10 peak/$0.05 off-peak on major expressways).

In Package B, vehicle charges and distance-based fees are assumed to have similar impacts to the feebates and gasoline taxes of Package A.

As with Package A, there are a number of interrelationships among the measures that cannot be quantified with certainty. For example, road pricing, parking pricing and vkt charges would all have an impact on user behaviour, possibly affecting similar trips. Generally, it was assumed that the combined impact of the demand-related measures (e.g., parking pricing, road pricing and vehicle charges) would be similar to the aggregate of the individual impacts. The impacts of the technology-related measures (e.g., vehicle taxes and vehicle I&M) on CO_2 emissions were also assumed to be equivalent to the sum of the individual measures, but the impacts were applied to the CO_2 from the reduced demand estimates.

Exhibit 4.3 summarizes the results of Package B, showing the estimated impacts if implemented with and without harmonization with the United States. The primary difference between these scenarios is that vehicle charges and taxes, if implemented North America-wide, would have a more profound impact on auto manufacturers and vehicle technologies. Under the harmonization scenario with the United States, the CO_2 reductions would be very significant. For passenger transportation modes, CO_2 emissions would be reduced by 30% from the baseline 2010 emissions. For freight transportation, emissions would be reduced by 15%. Overall, in comparison to the 1990 baseline emissions, the net impact of the measures would be in the order of an 11% reduction. Under the Canada-only scenario, the combined impact of the measures would be reduced somewhat, but the net result would still be significant. In fact, under the Canada-only scenario, Package B would nearly meet the Kyoto target when passenger and freight transportation are combined.

Exhibit 4.3

Impacts of Integrated Package B

	Annual CO_2 (Kilotonnes)			Change from 2010 Baseline			Change from 1990		
	Passenger	Freight	Total	Passenger	Freight	Total	Passenger	Freight	Total
1990	39,589	8,390	47,979	—	—	—			
2010 baseline	45,581	12,887	58,468	—	—	—	15%	54%	22%
2010 New Scenarios									
Canada only	33,716	11,930	45,645	-26%	-7%	-22%	-15%	42%	-5%
North America-wide	31,962	10,977	42,940	-30%	-15%	-27%	-19%	31%	-11%

Package C: *Comprehensive Package*

This package includes the direct road vehicle measures of Package A and the complementary road vehicle measures of Package B. It is assumed that the gasoline tax policy, coordinated among levels of government, would be used initially, without the use of other vehicle charge measures. Package C also includes policy options for enhancing transit, changing land use/urban design policies and other transportation demand management (TDM) policies.

The Comprehensive Package will unquestionably produce the greatest momentum toward sustainable transportation in the period to 2010. The Comprehensive Package will also set the stage for further progress in following decades.

The major synergies in the Comprehensive Package over Packages A and B relate to the parallel development and expansion of modal choice for the public and for businesses as personal vehicle use declines under the more direct policy initiatives. Options for expanding modal choice will clearly enhance the effectiveness of the measures targeted directly at personal vehicles.

In estimating the impacts of the Comprehensive Package, it was assumed that the regulatory measures would have the same impact as they would under the individual options. This assumption is based on the premise that the impact of the individual options would be enhanced if implemented in a comprehensive package, thereby balancing out the overlap between some of the measures. The impacts of the measures to expand modal choice were taken into account by increasing the elasticity of demand due to fuel taxes. This increase was based on the assumption that expanding modal choice would enhance the impacts of fuel taxes by providing more alternatives for people to reduce personal vehicle use. By increasing the elasticity of demand to fuel price from -0.15 to -0.2, the net impact is an approximate reduction in demand of 3.5% for the Canada-only case. This is a fairly moderate percentage reduction; however, it should be recognized that most of the options for expanding modal choice (e.g., land use and enhanced transit) will take a long time to take effect.

To illustrate the potential of a Comprehensive Package of options, the following assumptions were made regarding the intensity and implementation of the individual measures:

- a gasoline tax increase of 3 cents/litre/year starting in the year 2000;
- a diesel fuel tax increase of 3 cents/litre/year starting in the year 2000 (North America-wide package);
- CAFE/CAFC standards introduced in the year 2005;
- a feebate program introduced in 2005 (assuming a rate of $1,400/litre/100 kilometres);
- vehicle I&M with full implementation by 2000;
- parking pricing (5% annual increase from 2000 to 2010);

- road pricing ($0.10 peak/$0.05 off-peak on major expressways);
- TDM initiatives;
- enhanced transit; and
- land use/urban design.

Exhibit 4.4 summarizes the results of a comprehensive package of measures. Assuming the package is implemented in Canada only, CO_2 emissions from passenger transportation may be reduced by over 30% from the baseline 2010 emissions and by about 22% from the 1990 levels. Taking both passenger and freight transportation into account, the net impact of the Comprehensive Package was estimated to be an 11% reduction from 1990 levels, which exceeds the Kyoto target of 6%. It should be recognized that this is an illustrative scenario only, and that different price increases or regulatory controls would result in different reductions.

For the North America-wide case, the Comprehensive Package of options would meet the Kyoto targets, achieving a 20% reduction from 1990 levels when both passenger and freight modes are combined. As with the Canada only-scenario, freight transportation would not meet the targets on its own.

Exhibit 4.4

Impacts of Integrated Package C

	Annual CO_2 (Kilotonnes)			Change from 2010 Baseline			Change from 1990		
	Passenger	Freight	Total	Passenger	Freight	Total	Passenger	Freight	Total
1990	39,589	8,390	47,979	—	—	—			
2010 baseline	45,581	12,887	58,468	—	—	—	15%	54%	22%
2010 New Scenarios									
Canada only	31,060	11,604	42,663	-32%	-10%	-27%	-22%	38%	-11%
North America-wide	27,968	10,417	38,385	-39%	-19%	-34%	-29%	24%	-20%

Economic Implications of Integrated Packages

Macroeconomic Considerations

A potential barrier to implementing the policy changes that could enable the Kyoto target to be met is concern about possible negative effects on the national economy. There are, for example, specific concerns about the impacts on the automotive manufacturing and petroleum industries that are important to various regional economies in Canada.

The international literature regarding the economic impact of climate change policies and strategies is extensive. Perhaps even more so than the literature on the science of climate change, it is also inconclusive. Major reasons for the uncertainty regarding economic outcomes include structural differences in the national economies studied, the differences in the economic models used to estimate impacts, data limitations and differences in the assumptions used as inputs to model simulations. Repetto and Austin assert that:[61]

- Top-down models typically incorporate relatively little detail on energy consumption and technology change. Such models would not, for example, predict the economic impact of increased use of renewable energy in transportation as a result of new energy technologies, including wind, solar and biomass, now rapidly moving down the engineering cost curve; whereas

- Bottom-up models typically incorporate relatively little detail on non-energy consumer behaviour and interactions with other sectors.

In its 1995 report on the *Economic and Social Dimensions of Climate Change*, Working Group III of the Intergovernmental Panel on Climate Change (IPCC) drew the following broad conclusions from its extensive review of the literature about the macroeconomic impacts of mitigation and adaptation policy packages:[62]

- *... there is agreement that energy-efficiency gains of perhaps 10 to 30 percent above baseline trends over the next two to three decades can be realized at negative to zero net cost.*

- *For OECD countries, top-down (macroeconomic) studies suggest that the costs of substantial reductions below 1990 levels could be as high as several percent of GDP. In the specific case of stabilizing emissions at 1990 levels, most top-down macroeconomic studies estimate the annual costs in the range of minus 0.5% of GDP to plus 2% of GDP could be reached over the next several decades. In other words the range is from an increase in GDP of 0.5% to a decrease of 2%.*

- *Bottom-up studies (based on detailed studies of engineering costs and energy consumption) are more optimistic about the potential for low or negative cost emissions reductions and the capacity to implement that potential. Such studies show that the costs of reducing emissions by 20% in developed countries within two to three decades are negligible to negative. Other bottom-up studies suggest that there exists a potential for absolute reductions in excess of 50% in the longer term, without increasing, and perhaps even reducing, total energy system costs.*

- *Despite its widespread use in economic policy evaluation, GDP is widely recognized to be an imperfect measure of a society's well-being, largely because it fails to account for the degradation of natural systems.*

- *At both the international and national levels, the economic literature indicates that instruments that provide economic incentives, such as taxes and tradable quotas/permits, are likely to be more cost-effective than other approaches.*[63]

The use of economic instruments such as gasoline and diesel taxes, or other energy consumption-related measures such as vehicle registration fees or vkt charges, has the potential to raise very large tax revenues. The IPCC concludes that "how the revenue is distributed could dramatically affect the cost of mitigation. If the revenues are distributed by reducing distortionary taxes in the existing system, they will help reduce the tax burden of the existing tax system, potentially yielding an additional economic benefit (double dividend)."[64]

A recent study entitled *Energy Innovations*, by a group of U.S. environmental organizations, found that U.S. carbon emissions could be reduced by 10% from the 1990 level by 2010, while reducing annual energy costs from all sectors by US$530 per household and creating approximately 800,000 jobs. For the transportation sector, the U.S. study included many of the measures included in the integrated packages of this study of urban transportation in Canada. The U.S. study did not include a direct gasoline tax but did include "transportation pricing reforms including parking subsidy reform, uniform commuter benefits; shifting hidden, fixed or indirect costs to road users; pay-as-you-drive (distance based) insurance: and more equitable and environmentally sound road use cost allocation."[65] *Energy Innovations* places heavy emphasis on renewable energy and technology advances in transportation as driving elements of a U.S. climate change strategy. It concludes that by 2010, for an investment of $588 billion, cumulative savings would be $1,005 billion, for a cumulative benefit to cost ratio, over all sectors, of 1.7.

The January 1998 update of the Rational Energy Program proposed by the Sierra Club of Canada considered a range of measures for the transportation sector that are similar to those included in the integrated packages of the present study. However, the Sierra Club proposal differed in the assumptions made about specific measures. The Rational Energy Program, based on analyses by Natural Resources Canada, Informetrica and the Sierra Club of Canada, concludes that a national transportation strategy could reduce GHG emissions from transportation by 62.9 million tons by 2010, with cumulative net savings to the economy of $11.8 billion.

In a 1995 study, Informetrica concludes that "in the period 1995 to 2010, the overall size of the Canadian economy and its growth are unlikely to be significantly changed by initiatives designed to reduce emissions of Greenhouse Gases."[66] Despite wide variations in cumulative costs for households, governments and businesses for the scenarios analyzed, "the finding of small aggregate impact is invariant across the scenarios, since increased costs are matched by increased savings from reductions in energy use."

More recently, the Government of Canada commissioned Standard & Poor's DRI to prepare a report on the impacts of climate change mitigation activities on Canadian competitiveness. This report concluded that:

- "CO_2 abatement imposes transition costs on the Canadian economy;" and
- "policy choices matter."

More specifically, it concludes that:

Reducing CO_2 emissions will impose short- to medium-term transition costs on the Canadian economy. After ten to fifteen years (post 2013) the Canadian economy is expected to produce about the same level of output, albeit at reduced level of CO_2 emissions as it would have under Business-as-Usual conditions. The transition costs vary by region and sector. ... Because of their carbon-based economy, Alberta and Saskatchewan are most adversely affected both in the short and long term. British Columbia, Ontario and Quebec also experience significant costs until 2013 when output is forecast to rise above Business-as-Usual levels. ... This study has not addressed the issue of the benefits associated with climate change mitigation. Measurement of the benefits is required to determine the overall cost-effectiveness of the policy.[67]

For Canada as a whole, the DRI simulations suggest that the gross domestic product would be 2% to 3% lower than the business-as-usual (BAU) level for seven or eight years (e.g., between 2002 and 2010). There would be a lesser differential earlier and later in the transition period, and a positive impact (about 0.3% to 0.8% above the BAU level) during the period 2014 to 2020. The positive impact shows an increasing trend, but the simulation period ended at 2020. The estimated provincial impacts remain negative for Alberta and Saskatchewan through 2020. Ontario would experience a greater decrease (about 3% below the BAU level) during the period 2003 to 2008; however, it would, along with Quebec and British Columbia, experience a higher than average recovery after 2013 (a difference of 1% to 1.5% above the BAU level and rising) in the period 2014 to 2020.

The above estimated impacts are based on a "tradable permit scenario" assuming that CO_2 emissions are reduced to 1990 levels by 2010; they are similar for a "carbon tax scenario" aimed at a 10% CO_2 reduction by 2010 relative to 1990, except that the reductions during the transition period are slightly greater (about 3% to 3.5% below the BAU level for the period 2003 through 2010). However, the subsequent positive recovery is also greater (about 0.7% to 1.3% above the BAU level during the period 2015 to 2020, with a generally rising trend) at the national level.

The Cost Effectiveness of Fuel Economy Standards

CAFE/CAFC standards have been shown to be less cost effective than economic instruments that can be designed to target specific market behaviour. For example, Crandall and Nivola report that the mid-range of comparative studies of CAFE and fuel taxes shows that the gasoline tax assumed to match "CAFE's conservation effect would have reduced producer and consumer welfare by 8 cents a gallon saved, while the

regulatory alternative actually reduced welfare by around 60 cents a gallon saved."[68] The cost effectiveness of CAFE is also affected by the aggressiveness of the annual changes in the standards. For this study, we have assumed an annual improvement of 2%, suggested by the literature to be the closest to the least cost rate of technology uptake. For higher rates of improvement in fuel economy, manufacturers would incur higher costs to meet CAFE targets.

Wealth and Automobile Dependency

Recent research on the relationship between the gross regional product of urban regions worldwide and the nature of their urban densities and transportation systems has shown that "car use does not necessarily increase with increasing wealth, but tends to fall in the most wealthy cities. Where wealth is accompanied by land use and transport policies which do not facilitate car travel, car use (and energy cost) will be lower."[69]

Wealthy cities show strong use of public transit and especially rapid transit and commuter rail systems. "Rail transit systems (for large urban regions), compared to all other motorised transport, appear to have the best energy efficiency and greatest ability to attract people out of cars, ... are the most important factor in the recovery of transit operating costs, seem to be the catalyst for compact sub-centre development and make a major contribution to sustainability on all indicators. Transforming cities toward efficiency in both economic and environmental terms would appear to involve good rail systems."[70]

The Inefficiencies of Urban Sprawl

In addition to the energy cost inefficiencies of transportation in low-density urban regions, it has been shown that the costs of capital expansion and maintenance of all urban infrastructure including water and sewer systems, roads and other utilities resulting from urban sprawl are very high. The report of the Greater Toronto Task Force estimated that continued urban sprawl in the Greater Toronto Area over the next two decades would result in annual costs of $1 billion for capital and maintenance.[71] Similar conclusions have been drawn from studies of the Greater Vancouver Regional District.

The work of Australian researcher Jeff Kenworthy and others has clearly shown that population densities in the range of 30 persons/ha or more are required for financially viable public transit.[72] Such densities are found in the core of some Canadian cities, but not in their suburban regions.

The American researcher David Aschauer has found that "within the broad category of transportation spending, the evidence indicates that public transit spending carries more potential to stimulate long run economic growth than does highway spending."[73]

Although this Backgrounder focuses on urban transportation in Canada, most of the literature on economic impacts of climate change policies for transportation does not distinguish between urban and non-urban segments. On the assumption that there are more opportunities for cost effective alternatives to high energy intensive modes for passenger and freight movement in urban areas, it seems reasonable to expect policy measures to have somewhat larger positive economic and social impacts in cities than in rural areas. From the available data, however, this assumption cannot be confirmed.

Positions of the Auto and Petroleum Industries

Consensus among major stakeholders about sectoral economic impacts will be difficult to achieve. This is strikingly illustrated in a report to the President of the United States by the Policy Dialogue Committee (known as the Cartalk Group). The majority report of this multistakeholder body states that: "The Committee ... was unable to reconcile the following positions: Environmentalists favored fuel economy standards, which the auto industry opposed. The automobile industry proposed gas taxes to which the oil industry representatives objected. Finally a consensus report stating the Committee's disagreement was unacceptable to the auto industry if it mentioned direct measures to increase fuel economy in a quantified way."[74] The positions of stakeholders to date in Canada have been similar.

Many studies have suggested that a portion of revenues from increased fuel taxes or other market-based economic measures can be dedicated to funding other initiatives, such as enhanced public transit and other TDM policies. The Transportation Association of Canada has proposed that the majority of money collected from fuel taxes and licence fees be identified as taxes and retained as general revenues. Moreover, an appropriate portion should be identified as a transportation fee and dedicated to urban transportation in support of local visions. Any future increases to either the general revenue tax or the dedicated urban transportation fee would be identified as such at the time.[75]

Conclusions on Economic Impacts

The following broad conclusions can be drawn from the above discussion of the literature on the economic impacts of policy options for mitigating climate change impacts of rising GHG concentrations:

- There is uncertainty about estimates of economic impacts of GHG-related policies. Such estimates are very sensitive to the econometric models and assumptions used.
- There is general agreement among economists that energy efficiency gains of 10% to 30% above baseline trends over the next two to three decades can be achieved at negative to zero net cost.
- Policy instruments such as taxes and tradable quotas/permits are likely to be more cost effective than other approaches.
- Tax revenues from GHG-related policies can be used to reduce distortionary taxes in the existing system, potentially yielding additional economic benefit.
- The wealthiest global cities are not highly dependent on road vehicles.
- Urban sprawl is costly.
- Effective policies for reducing GHG emissions will affect some industries and regions more than others. Impacts can be softened by implementing policies over extended periods and by private and public sector strategies for adapting to the changing policies.

Assessment of Integrated Packages

Five broad criteria have been selected as a means for discussing and assessing the integrated packages:

- GHG reduction;
- cost;
- economic impacts;
- ease of implementation; and
- social impacts.

Exhibit 4.5 presents a summary of the assessment of the integrated packages based on these five criteria.

Exhibit 4.5

Assessment of Integrated Packages

		Package A Road Vehicles — Basic		Package B Road Vehicles — Alternative		Package C Comprehensive Package	
		Canada only	North America-wide	Canada only	North America-wide	Canada only	North America-wide
GHG Impacts: Summary							
Reduction from 2010 baseline		-14%	-24%	-22%	-27%	-27%	-34%
Reduction from 1990 baseline		+5%	-7%	-5%	-11%	-11%	-20%
Evaluation Criteria	**Objective**						
Greenhouse gas reduction	To meet or exceed Kyoto target reductions	Low	Medium	Medium	High	High	High
Public sector cost	To be implemented without significantly increased net costs to the public sector	High	High	Medium	Medium	Low	Low
Economic impacts	To be implemented without reducing Canada's economic efficiency	Low	Medium	Low	Medium	Medium	High
Ease of early implementation	To be implemented such that impacts are realized by 2010	High	Medium	High	Medium	Medium	Low
Social impacts	To be implemented while improving social equity	Medium	Medium	Low	Low	High	High
Overall Assessment		Medium	High	Low	Medium	High	High

Extent to which objectives are satisfied: Low Medium High

The assessment was largely subjective, drawing on the material presented in the previous two chapters. A discussion of the extent to which each of the options meets each criterion is provided below.

Greenhouse Gas Reduction

In terms of GHG reduction, the effectiveness of the options generally increases as more measures are added. In Package A, two of the three measures (CAFE/CAFC and feebates) would not have realized their full potential by the year 2010. Fuel taxes, the primary measure in this package, would also take some time to have an impact on technology, fleet efficiency and demand impacts. The lack of measures to expand modal choice limits the potential effectiveness of fuel taxes in Package A. The net effect of the integrated measures in Package A is a fairly moderate reduction in CO_2 emissions. This results in low and medium ratings for the Canada-only case and North America-wide scenario respectively. The advantages of achieving harmonization with the United States are very apparent in Package A. If harmonization does occur, the integrated measures in Package A have the potential to result in reductions equal to or greater than the Kyoto target.

Most of the options in Package B will have a more direct impact on the use of vehicles, compared to the options in Package A. The Canada-only case would fall just short of the Kyoto target, while the North America-wide case would exceed the target by a significant margin.

Of all the packages, Package C demonstrates the greatest potential to reduce CO_2 significantly. This is largely due to the synergistic effects that the options to expand modal choice have on the other measures and the large number of measures targeted at specific behavioural decisions. Package C is given high ratings for both the Canada-only and North America-wide scenarios.

Public Sector Cost

There are several ways in which cost could be assessed. For the purpose of this assessment, the options have been assessed in terms of their ability to be implemented without significantly increasing costs to the public sector. In contrast to economic impacts, which are a separate criterion, the cost criterion relates more to the direct internalized costs to the public sector, excluding environmental costs and other external costs.

Based on our definition of cost, Package A would likely have the lowest cost to the public sector, and is therefore given the highest rating. In fact, the fuel tax measure under Package A would generate a significant revenue surplus, which governments could use to adjust the distribution impacts of existing tax systems. Package B may have somewhat more substantial costs than Package A, given that most of the measures would have non-trivial operating and capital costs. For example, road pricing (e.g., road tolls) would require a physical collection mechanism to be built, operated and maintained. Likewise, vehicle inspection and maintenance programs require initial investment to set up the actual testing stations (which are to be privately owned in Ontario). Some or all of the costs to implement these measures would be recovered through user fees.

In terms of public sector costs, Package C would likely be the most expensive. The costs of Package C include capital and operating costs of the measures in Packages A and B plus substantial costs to expand options for modal choice, for example, investment in transit infrastructure. Package C has therefore been given a low rating in this regard, although its net cost to the public sector could be quite low (while higher than those for Package B or A or even negative if user revenues — e.g., from gas tax revenues, parking surcharges or road tolls — are used to fund these investments).

Economic Impacts

The section "Economic Implications of Integrated Packages" (see page 66) provided a broad overview of the likely economic impacts of achieving reductions in CO_2 emissions. Our general conclusion based on the literature is that measures that reduce CO_2 can improve economic efficiency. Further, measures that reduce CO_2 also reduce the costs associated with environmental damage, accidents and other externalities. The three packages were therefore rated in terms of their ability to improve economic efficiency. Under this criterion, Packages A and B are given low to medium ratings and Package C a medium to high rating. In all aspects, including improving economic efficiency, the packages are enhanced if implemented on a North America-wide basis. There are clearly economic benefits associated with being able to share the costs of improving vehicle technology with the United States.

Ease of Early Implementation

Several criteria could be used to reflect the ease of implementation of the various measures and packages. Perhaps the most relevant is the ability of the measures in each package to be implemented such that their impacts are felt by the 2010 horizon. In terms of ease of implementation, Package A and Package B both contain measures that are relatively easily implemented. The higher rating for the Canada-only case reflects the fact that potentially lengthy negotiations with the United States would not be required.

Social Impacts

Social impacts can be assessed based on a number of criteria including material wealth, social polarization, community relationships, health and safety and even cultural diversity. Under Package A, feebates would reduce the purchase cost of fuel efficient cars relative to more energy-consuming, emission-producing vehicles. In turn, this would reduce the cost of car ownership for people with lower incomes who require the use of a car for work or other purposes. Because Package B contains a number of direct user-pay initiatives, it may have more measurable social impacts than Package A. In particular, people with lower incomes might not be able to afford the costs of driving, whereas people with higher incomes could, thereby increasing social polarization. In Package C, the measures to expand modal choice should provide considerable benefit to individuals with lower incomes given that they would have more travel options. Another key advantage of Package C is that the restructuring of land use could serve to enhance community relationships. Unfortunately, some of the options to expand modal choice (e.g., expanding transit infrastructure) as well as land use measures are longer-term initiatives.

Overall Assessment

All of the integrated packages move in the right direction; however, some packages have obvious benefits over others. Exhibit 4.5 presents a largely subjective assessment of the three packages in overall terms. Based on the five broad criteria, it would appear that Package C offers the greatest benefits with the least negative impacts. Package C has many other advantages besides GHG reduction. In particular, the individual measures in Package C represent a balance between regulatory measures and more passive measures to expand modal choice. Package C also generates the broadest momentum for greater emissions reductions, which may be required beyond the time frame of the Kyoto Protocol.

5

Conclusions

Based upon the findings of this study as summarized earlier, the following conclusions are drawn.

- Policy options to reduce urban transportation GHG emissions that involve a single initiative only are unlikely to achieve the Kyoto target (see Exhibit 3.14).
- Combinations of the individual initiatives show more promise, and three such combination packages were developed for analysis (see Exhibit 4.1).
- Any one of the three combination packages, with the exception of Package A and Package B if applied in Canada only, is estimated to meet the Kyoto target. Package C, the Comprehensive Package, is likely to achieve the greatest reductions (see Exhibit 3 in the Executive Summary). Any of the packages would also build momentum for substantial CO_2 reduction trends beyond 2010, with Package C again being the most effective in this regard.
- When other objectives, such as reasonable public sector costs, economic efficiency, ease of early implementation and reasonable social impacts, are taken into account as well as GHG reduction, the Comprehensive Package achieves the highest rating in a comparative evaluation (see Exhibit 4.5).
- Based on the above, we conclude that it would be feasible for Canada, acting alone, to achieve its Kyoto emissions reduction target for urban transportation in the country's 13 largest CMAs, which account for some 80% of urban transportation GHG emissions in this country. This conclusion is significantly strengthened if any one of the three combined packages could be implemented North America-wide. The likelihood of success is also increased if more initiatives are added to the package.

Clearly, the complexity and challenges of achieving the cooperation required for combined approaches increase as the field of action moves from Package A to Package B and onward to Package C. However, the rewards of accepting these challenges make the effort worthwhile in terms of meeting and exceeding the Kyoto target, while also achieving other objectives (e.g., financial, economic, social). Similarly, the benefits from achieving a harmonized approach across North America warrant the additional effort of attempting to achieve a cooperative approach by the three national governments of Canada, the United States and Mexico. It is fortunate that, based on the findings of this study, there is excellent promise that the Kyoto target can be reached for GHG emissions from urban transportation in Canada through largely federal initiatives. Thus there is good reason to act on these initiatives as soon as possible, while initiating discussions with other jurisdictions in hopes of achieving broadened, cooperative approaches.

Endnotes

1 Transportation Association of Canada, *A Primer on Urban Transportation and Global Climate Change* (Ottawa, May 1998).

2 I. Karl, N. Nicholls and J. Gregory, "The Coming Climate," *Scientific American* (May 1997), p. 79.

3 The top 13 CMAs in declining order of population are Toronto, Montreal, Vancouver, Ottawa-Hull, Edmonton, Calgary, Quebec City, Winnipeg, Hamilton, London, Kitchener, St. Catharines-Niagara and Halifax.

4 Transport Canada, Environment Canada, Natural Resources Canada, Department of Finance Canada and Industry Canada, with the assistance of Marbek Resource Consultants, *Foundation Paper on Climate Change — Transportation Sector Initial Draft* (Ottawa, June 1998).

5 John Lawson, Transport Canada, *Canada's Commitment on Greenhouse Gas Emissions under the Kyoto Protocol and the Potential for Reductions in Transport*, presentation to the Canadian Transportation Research Forum 33rd Annual Conference, Edmonton, Alberta, May 25-28, 1998. (Note: In developing Exhibit 2.5, 20% of the emissions from international aviation and 100% from marine modes were estimated to be from freight transportation.)

6 John Hartman, Transportation Association of Canada, Presentation to National Air Issues Co-ordination Committee Conference on Transportation and Climate Change, Toronto, April 2, 1998.

7 R. Crandall and P. Nivola, *The Extra Mile: Rethinking Energy Policy for Automotive Transportation* (Washington, D.C.: The Brookings Institute, 1995), p. 28.

8 Ibid.

9 P.B. Goodwin, "A Review of New Demand Elasticities with Specific Reference to Short and Long Run Effect on Price Changes," *Journal of Transport Economics and Policy*, Vol. 26, No. 2 (May 1992).

10 R. Soberman and E. Miller, *Full Cost Pricing and Sustainable Urban Transportation: A Case Study of the Greater Toronto Area* (University of Toronto, November 1997).

11 L. Michaelis, *Annex I Expert Group on the UN FCCC, Working Paper 1, Policies and Measures for Common Action — Sustainable Transport Policies: CO_2 Emissions from Road Vehicles* (Paris: OECD, July 1996).

12 Ibid.

13 The Osborne Group, DesRosiers Automotive Consultants and Pilorusso Research and Consulting, *Reducing Greenhouse Gas Emissions from the Ontario Automotive Sector* (Toronto: Transportation and Climate Change Collaborative, May 1995), p. 8.

14 R. Crandall and P. Nivola, *The Extra Mile: Rethinking Energy Policy for Automotive Transportation* (Washington, D.C.: The Brookings Institute, 1995), p. 24.

15 Ibid., p. 40.

16 Ibid., p. 39.

17 K.G. Duleep, Energy and Environmental Analysis Inc., personal communication, August 1998.

18 L. Michaelis, *Annex I Expert Group on the UN FCCC, Working Paper 1, Policies and Measures for Common Action — Sustainable Transport Policies: CO_2 Emissions from Road Vehicles* (Paris: OECD, July 1996), p. 44.

19 The assumption of 2% improvement in new vehicle fuel economy under a new CAFE/CAFC program reflects the fuel efficiency technology that can be applied by manufacturers within the discounted value of fuel savings. This rate is derived from Ibid., Fig. 10, p. 33.

20 Natural Resources Canada, *Canada's Energy Outlook 1990-2020* (Ottawa, April 1997).

21 L. Michaelis, *Annex I Expert Group on the UN FCCC, Working Paper 1, Policies and Measures for Common Action — Sustainable Transport Policies: CO_2 Emissions from Road Vehicles* (Paris: OECD, July 1996), p. 35.

22 Ibid., Table 6, p. 41.

23 Pembina Institute, *Reducing Greenhouse Gas Emissions in Canada, Success Stories and Their Potential for Broader Replication* (Drayton Valley, Alberta, Spring 1998).

24 Ibid., p. 36.

25 *Ontario's Smog Plan, A Partnership for Collective Action*, Steering Committee Report (Toronto: Ontario Ministry of the Environment, January 1998), p. vi.

26 The Osborne Group, DesRosiers Automotive Consultants and Pilorusso Research and Consulting, *Reducing Greenhouse Gas Emissions from the Ontario Automotive Sector* (Toronto: Transportation and Climate Change Collaborative, May 1995), p. 48.

27 L. Michaelis, *Annex I Expert Group on the UN FCCC, Working Paper 1, Policies and Measures for Common Action — Sustainable Transport Policies: CO_2 Emissions from Road Vehicles* (Paris: OECD, July 1996), p. 23.

28 Todd Litman, Victoria Transport Policy Institute, "Distance Based Vehicle Insurance as a TDM Strategy," *Transportation Quarterly*, Vol. 51 (Summer 1997), pp. 119-138.

29 Ibid.

30 Ibid. Cites B.C. Transportation Financing Authority and Greater Vancouver Regional District, *Transportation Demand Management: A Quantitative Analysis of Public Views* (Burnaby, 1996).

31 Donald Shoup, "An Opportunity to Reduce Minimum Parking Requirements," *APA Journal* (Winter 1995), p. 14.

32 Ibid., p. 15.

33 Regional Transportation Authority of Chicago, *An Assessment of Travel Pricing Strategies* (Chicago, September 1994), p. 14.

34 "Mixed Use Development in Los Angeles," *Urban Ecologist* (Winter 1993).

35 Apogee Research, *Policy Instruments Working Paper on Reducing CO_2 Emissions from the Transport Sector in Ontario* (Toronto: Transportation and Climate Change Collaborative, 1995), p. 74.

36 E. Miller, *Modelling Central Area Work Trip Modal Choice and Parking Demand* (Toronto: City of Toronto Planning and Development Department, June 1992), p. 51.

37 University of Toronto Joint Program in Transportation, Data Management Group, *The Transportation Tomorrow Survey* (Toronto, 1996).

38 Transportation Association of Canada, *Financing Urban Transportation* (Ottawa, February 1997), p. 2.

39 Calgary GOPlan, *Calgary Downtown Parking and Transit Study Summary Report* (Calgary, March 1994), p. 5.

40 The Osborne Group, DesRosiers Automotive Consultants and Pilorusso Research and Consulting, *Reducing Greenhouse Gas Emissions from the Ontario Automotive Sector* (Toronto: Transportation and Climate Change Collaborative, May 1995).

41 Dave Hermance, General Manager, Powertrain, Toyota Technical Centre, presentation made in 1998.

42 Cheminfo, *Climate Change Technologies and Canadian Supply Capabilities — A Scoping Study* (Ottawa: Industry Canada, May 1998).

43 Centre for Sustainable Transportation, *Sustainable Transportation Monitor*, No. 1 (March 1998), p. 6.

44 John Lawson, Transport Canada, *Canada's Commitment on Greenhouse Gas Emissions under the Kyoto Protocol and the Potential for Reductions in Transport*, presentation to the Canadian Transportation Research Forum 33rd Annual Conference, Edmonton, Alberta, May 25-28, 1998, p. 9.

45 Canadian Urban Transit Association, *Transit Fact Book* (Toronto, 1996).

46 Ralph Torrie, *Transportation Quantification and Indicators in the Cities for Climate Protection Campaign*, presentation to Moving the Economy Conference, Toronto, July 11, 1998.

47 U.S. Bureau of Transportation Statistics, *National Transportation Statistics* (Washington, D.C., 1997).

48 Pollution Probe, Canadian Urban Transit Association, Toronto Transit Commission, *Trans-Action 98* (Toronto, May 1998).

49 David Engwicht, *Reclaiming Our Cities and Towns* (Gabriola Island, B.C.: New Society Publishers, 1993), p. 17.

50 J. Kenworthy et al., Murdoch University, Australia, *Indicators of Transport Efficiency in 37 Global Cities* (Washington, D.C.: World Bank, February 1997), p. 5.

51 Ibid., p. 12.

52 Greater Toronto Task Force, *Report of the Greater Toronto Task Force* (Toronto: Queen's Printer for Ontario, January 1996), p. 111.

53 McCormick Rankin Corporation, *Transportation Demand Management in the GTA* (Toronto, January 1998); TDM Working Group, *TDM Working Group Report to Ontario's Smog Plan Steering Committee*, unpublished, May 21, 1997; Todd Litman, *Win-Win Transportation Management Strategies* (Victoria Transport Policy Institute, 1998); Pollution Probe, Canadian Urban Transit Association, Toronto Transit Commission, *Trans-Action 98* (Toronto, May 1998).

54 GO Transit, *GO Transit Year 2021 Plan* (Toronto, February 1998), p. 7.

55 David Engwicht, *Reclaiming Our Cities and Towns* (Gabriola Island, B.C.: New Society Publishers, 1993), p. 83.

56 Phil Day, "Traffic Calming," *Queensland Planner*, Vol. 29, No. 1 (1989), p. 2. (Published by the Royal Australian Planning Institute, Brisbane.)

57 David Engwicht, *Reclaiming Our Cities and Towns* (Gabriola Island, B.C.: New Society Publishers), p. 129.

58 Liz Reynolds, Auto Share, Toronto, *Greenhouse Gas Impacts of Car Sharing*, personal communication, July 1998.

59 Ibid.

60 Based on preliminary work carried out by IBI Group and A.K. Socio-Technical Consultants for Environment Canada as part of the OECD Environmentally Sustainable Transportation (EST) Study.

61 R. Repetto and D. Austin, *The Costs of Climate Protection: A Guide for the Perplexed* (Washington, D.C.: World Resources Institute, 1997).

62 Intergovernmental Panel on Climate Change (IPCC), *Climate Change 1995, Economic and Social Dimensions of Climate Change*, Contribution of Working Group III to the Second Assessment Report of the IPCC (Cambridge: Cambridge University Press, 1995) (Summary for Policy Makers). Co-editors, along with Hoesung Lee of Korea, were Canadians James Bruce of the Canadian Climate Program Board and Erik Haites of Margaree Consultants Inc.

63 Ibid., p. 13, Box S.1: Top-Down and Bottom-Up Models.

64 Ibid., p. 13.

65 Alliance to Save Energy, American Council for an Energy-Efficient Economy, *Energy Innovations: A Prosperous Path to a Clean Environment* (Washington, D.C.: Natural Resources Defense Council, Tellus Institute and Union of Concerned Scientists, 1997), Executive Summary — A Greener Way to Go.

66 C.A. Sonnen and M.C. Justus, Informetrica, *Impact of GHG Initiatives on the National and Provincial Economies* (Ottawa: The Forecast Working Group of the National Air Issues Co-ordinating Mechanism, April 1995).

67 Standard & Poor's DRI, *Impacts on Canadian Competitiveness of International Climate Change Mitigation: Phase II* (Ottawa: Environment Canada, Natural Resources Canada, Industry Canada, Department of Finance, and Department of Foreign Affairs and International Trade, November 1997).

68 R. Crandall and P. Nivola, *The Extra Mile: Rethinking Energy Policy for Automotive Transportation* (Washington, D.C.: The Brookings Institute, 1995), p. 33.

69 J. Kenworthy et al., Murdoch University, Australia, *Indicators of Transport Efficiency in 37 Global Cities* (Washington, D.C.: World Bank, February 1997), p. 5.

70 Ibid.

71 Greater Toronto Task Force, *Report of the Greater Toronto Task Force* (Toronto: Queen's Printer for Ontario, January 1996), p. 111.

72 J. Kenworthy et al., Murdoch University, Australia, *Indicators of Transport Efficiency in 37 Global Cities* (Washington, D.C.: World Bank, February 1997), p. 23.

73 D.A. Aschauer and E.J. Campbell, Bates College, *Transportation Spending and Economic Growth*, reported in *Earthword: The Journal of Environmental and Social Responsibility*, Vol. 4, No. 38 (1991).

74 Policy Dialogue Committee, *Majority Report to the President by the Policy Dialogue Advisory Committee to Recommend Options for Reducing Greenhouse Gas Emissions from Personal Motor Vehicles* (Washington, D.C., 1997), Executive Summary.

75 Transportation Association of Canada, *Financing Urban Transportation*, Briefing (Ottawa, February 1997), p. 5.

Bibliography

Alliance to Save Energy, American Council for an Energy-Efficient Economy. 1997. *Energy Innovations: A Prosperous Path to a Clean Environment.* Washington, D.C.: Natural Resources Defense Council, Tellus Institute and Union of Concerned Scientists. Executive Summary – A Greener Way to Go.

Apogee Research. 1995. *A Policy Instrument Working Paper on Reducing CO_2 Emissions from the Transport Sector in Ontario.* Toronto: Ontario Transportation and Climate Change Collaborative.

Apogee Research and Management of Technology Services. 1996. *Backgrounder on Sustainable Transportation in Canada.* Ottawa: National Round Table on the Environment and the Economy.

Aschauer, D.A., and Campbell, E.J., Bates College. 1991. "Transportation Spending and Economic Growth." Reported in *Earthword: The Journal of Environmental and Social Responsibility*, Vol. 4, No. 38.

B.C. Transportation Financing Authority and Greater Vancouver Regional District. 1996. *Transportation Demand Management: A Quantitative Analysis of Public Views.* Burnaby.

Calgary GOPlan. March 1994. *Calgary Downtown Parking and Transit Study Summary Report.* Calgary.

Canadian Urban Transit Association. 1996. *Transit Fact Book.* Toronto.

Centre for Sustainable Transportation. 1998. *Sustainable Transportation Monitor,* No. 1 (March).

Centre for Sustainable Transportation. April 1998. *Reflections on the Movement of People and of Freight with Special Attention to the Role of the Private Automobile.* Inquiries for a Sustainable Future. Toronto.

Centre for Sustainable Transportation. July 1998. *Report on the Effectiveness of Measures.* Toronto.

Cheminfo. May 1998. *Climate Change Technologies and Canadian Supply Capabilities — A Scoping Study.* Ottawa: Industry Canada.

Crandall, R., and Nivola, P. 1995. *The Extra Mile: Rethinking Energy Policy for Automotive Transportation.* Washington, D.C.: The Brookings Institute.

David Suzuki Foundation and Pembina Institute. April 1998. *Canadian Solutions — Meeting Our Kyoto Commitment: Climate Action Basics for Canada.* Vancouver/Drayton Valley, Alberta.

Day, P. 1989. "Traffic Calming." *Queensland Planner*, Vol. 29, No. 1. (Published by the Royal Australian Planning Institute, Brisbane.)

DeCicco, J., and Delucchi, M. 1997. *Transportation, Energy and Environment: How Far Can Technology Take Us?* Washington, D.C.: American Council for an Energy-Efficient Economy.

Duleep, K.G. August 1998. Energy and Environmental Analysis, Inc. Personal communication.

Engwicht, D. 1993. *Reclaiming Our Cities and Towns.* Gabriola Island, B.C., New Society Publishers.

Environment Canada. December 1992. *Canada's Greenhouse Gas Emissions: Estimate for 1990.* Report EPS 5/AP/4. Ottawa.

Environment Canada. 1993. *A Matter of Degrees: A Primer on Climate Change.* Ottawa.

Environment Canada. April 1997. *Trends in Canada's Greenhouse Gas Emissions, 1990-1995.* Ottawa.

European Conference of Ministers of Transport/OECD. 1995. *Urban Travel and Sustainable Development.* Paris.

Flavin, C., and Dunn, S. November 1997. *Rising Sun, Gathering Winds: Policies to Stabilize the Climate and Strengthen Economies.* Worldwatch Paper 138. Washington, D.C.: Worldwatch Institute.

Flavin, C., and Tunali, O. June 1996. *Climate of Hope: New Strategies for Stabilizing the World's Atmosphere.* Worldwatch Paper 130. Washington, D.C.: Worldwatch Institute.

GO Transit. February 1998. *GO Transit Year 2021 Plan.* Toronto.

Goodwin, P.B. May 1992. "A Review of New Demand Elasticities with Specific Reference to Short and Long Run Effect on Price Changes." *Journal of Transport Economics and Policy,* Vol. 26, No. 2.

Government of Canada. May 1997. *Canada's Second National Report on Climate Change: Actions to Meet Commitments Under the United Nations Framework Convention on Climate Change.* Ottawa.

Greater Toronto Task Force. January 1996. *Report of the Greater Toronto Task Force.* Toronto: Queen's Printer for Toronto.

Greene, D.L., and Santini, D.J. 1993. *Transportation and Global Climate Change,* Washington, D.C.: American Council for an Energy-Efficient Economy.

Grubb, M., Chapuis, T., and Duong, M.H. 1995. "The Economics of Changing Course: Implications of Adaptability and Inertia for Optimal Climate Policy." *Energy Policy*, Vol. 23, No. 415.

Hartman, J., Transportation Association of Canada. April 2, 1998. Presentation to National Air Issues Co-ordination Committee Conference on Transportation and Climate Change, Toronto.

IBI Group. March 1995. *Urban Planning, Public Transit and Related Initiatives for More Sustainable Urban Transportation.* Toronto: Transportation and Climate Change Collaborative.

IBI Group. November 1995. *Full Cost Transportation and Cost Based Pricing Strategies.* Toronto: Transportation and Climate Change Collaborative.

Intergovernmental Panel on Climate Change (IPCC). 1995. *Climate Change 1995, Economic and Social Dimensions of Climate Change.* Contribution of Working Group III to the Second Assessment Report of the IPCC. Cambridge, U.K.: Cambridge University Press. Summary for Policy Makers.

Intergovernmental Panel on Climate Change (IPCC). 1995. *Climate Change 1995, The Science of Climate Change,* Contribution of Working Group I to the Second Assessment Report of the IPCC. Cambridge, U.K.: Cambridge University Press.

International Energy Agency/OECD. 1993. *Cars and Climate Change.* Paris.

John D. Hutchison Consulting. June 1998. *Vehicle Inspection and Maintenance: What It Is and Why We Need It.* Toronto: Pollution Probe.

Kageson, P. 1994. *Effects of Internalisation on Transport Demand and Modal Split.* Paris: European Conference of Ministers of Transport/OECD.

Karl, I.T., Nicholls, N., and Gregory, J. 1997. "The Coming Climate." *Scientific American.*

Kenworthy J. et al., Murdoch University, Australia. February 1997. *Indicators of Transport Efficiency in 37 Global Cities.* Washington, D.C.: World Bank.

Koopman, G.J. January 1995. "Policies to Reduce CO_2 Emissions from Cars in Europe: A Partial Equilibrium Analysis." *Journal of Transport Economics and Policy*, Vol. 29, No. 1.

Lawson, J. 1998. *Canada's Commitment on Greenhouse Gas Emissions under the Kyoto Protocol and the Potential for Reductions in Transport.* Presentation to the Canadian Transportation Research Forum 33rd Annual Conference, Edmonton, Alberta, May 25-28.

Litman, T. 1997. "Distance Based Vehicle Insurance as a TDM Strategy." *Transportation Quarterly*, Vol. 51 (Summer).

Litman, T. 1998. *Win-Win Transportation Management Strategies.* Victoria, B.C.: Victoria Transport Policy Institute.

Management of Technology Services and Apogee Research. November 1997. *State of the Debate Report: The Road to Sustainable Transportation in Canada.* Ottawa: National Round Table on the Environment and the Economy.

McCormick Rankin Corporation. January 1997. *Transportation Demand Management in the GTA.* Toronto: Ontario Ministry of Transportation of Ontario.

Michaelis, L. July 1996. *Annex I Expert Group on the UN FCCC, Working Paper 1, Policies and Measures for Common Action — Sustainable Transport Policies: CO_2 Emissions from Road Vehicles.* Paris: OECD.

Miller, E. June 1992. *Modelling Central Area Work Trip Modal Choice and Parking Demand.* Toronto: City of Toronto Planning and Development Department.

Munich Re. 1997. *Topic: An Annual Review of Natural Catastrophes.* Corporate document. Munich, Germany.

Natural Resources Canada. April 1997. *Canada's Energy Outlook 1990-2020.* Ottawa.

Ontario's Smog Plan: A Partnership for Collective Action. January 1998. Steering Committee Report. Toronto: Ontario Ministry of Environment.

Organization for Economic Cooperation and Development. 1997. *Towards Sustainable Transportation, The Vancouver Conference.* Proceedings. Paris.

Organization for Economic Cooperation and Development, Environment Directorate. In progress. *Project on Environmentally Sustainable Transport.*

The Osborne Group, DesRosiers Automotive Consultants and Pilorusso Research and Consulting, May 1995. *Reducing Greenhouse Gas Emissions from the Ontario Automotive Sector.* Toronto: Transportation and Climate Change Collaborative.

Pembina Institute. Spring 1998. *Reducing Greenhouse Gas Emissions in Canada: Success Stories and Their Potential for Broader Replication.* Drayton Valley, Alberta.

Pilorusso Research and Consulting. May 1995. *The Role of Transportation Technologies in Reducing Greenhouse Gas Emissions.* Transportation and Climate Change Collaborative. Toronto.

Policy Dialogue Advisory Committee. 1997. *Majority Report to the President by the Policy Dialogue Advisory Committee to Recommend Options for Reducing Greenhouse Gas Emissions from Personal Motor Vehicles.* Washington, D.C. Executive Summary.

Pollution Probe, Canadian Urban Transit Association and Toronto Transit Commission. May 1998. *Trans-Action 98.* Toronto.

Pollution Probe and York University. April 1996. *Proceedings of the Transportation, Air Quality and Human Health Conference.* Toronto.

Pulcher, J., and Lefevre, C. 1996. *The Urban Transport Crisis in Europe and North America.* London: Macmillan Press Ltd.

Regional Transportation Authority of Chicago. September 1994. *An Assessment of Travel Pricing Strategies.* Chicago.

Repetto, R., and Austin, D. 1997. *The Costs of Climate Protection: A Guide for the Perplexed.* Washington, D.C.: World Resources Institute.

Reynolds, L. July 1998. *Greenhouse Gas Impacts of Car Sharing.* Toronto: Auto Share.

Roodman, D.M. May 1997. *Getting the Signals Right: Tax Reform to Protect the Environment and the Economy.* Worldwatch Paper 134. Washington, D.C.: Worldwatch Institute.

Royal Institute of International Affairs. February 1998. *G-8 Environment and Transport Futures Forum.* London.

Shoup, D. 1995. "An Opportunity to Reduce Minimum Parking Requirements." *APA Journal* (Winter).

Soberman, R., and Miller, E. November 1997. *Full Cost Pricing and Sustainable Urban Transportation: A Case Study of the Greater Toronto Area.* Toronto: University of Toronto.

Sonnen, C.A., and Justus, M.C., Informetrica. April 1995. *Impact of GHG Initiatives on the National and Provincial Economies.* Ottawa: The Forecast Working Group of the National Air Issues Co-ordinating Mechanism.

Sperling, D., and Shaheen, S. 1995. *Transportation and Energy: Strategies for a Sustainable Transportation System.* Washington, D.C.: American Council for an Energy-Efficient Economy.

Standard & Poor's DRI. November 1997. *Impacts on Canadian Competitiveness of International Climate Change Mitigation: Phase II.* Ottawa: Environment Canada, Natural Resources Canada, Industry Canada, Department of Finance, and Department of Foreign Affairs and International Trade.

Swiss Reinsurance Company. 1986. *Environmental Changes and Catastrophe Hazards.* Zurich.

Swiss Reinsurance Company. 1994. *Global Warming: Element of Risk.* Zurich.

TDM Working Group. May 21, 1997. *TDM Working Group Report to Ontario's Smog Plan Steering Committee.* Unpublished.

Terzis, G., Dix, M., Bates, J., and Dawe, G. September 1995. "Effects and Elasticities of Higher Fuel Prices." *Transport Policy and Its Implementation: Proceedings of Seminar E.* Conference held at the PTRC European Transport Forum, University of Warwick, England, September 11-15, 1995. London: PTRC Education Research Services on behalf of the Planning and Transport Research and Computation International Association, pp. 247-259.

Torrie, R. *Transportation Quantification and Indicators in the Cities for Climate Protection Campaign.* Presentation to the Moving the Economy Conference, Toronto, July 11, 1998.

Transport Canada. 1997. *Transportation in Canada — 1996.* Annual Report. Ottawa.

Transport Canada, Environment Canada, Natural Resources Canada, Department of Finance Canada and Industry Canada with the assistance of Marbeck Resource Consultants. June 1998. *Foundation Paper on Climate Change — Transportation Sector Initial Draft.* Ottawa.

Transportation and Climate Change Collaborative. November 1995. *A Strategy for Sustainable Transportation in Ontario.* Toronto.

Transportation Association of Canada. February 1997. *Financing Urban Transportation.* Ottawa.

Transportation Association of Canada. May 1998. *A Primer on Urban Transportation and Global Climate Change.* Ottawa.

University of Toronto Joint Program in Transportation, Data Management Group. 1996. *The Transportation Tomorrow Survey.* Toronto.

"Mixed Use Development in Los Angeles." *Urban Ecologist.* Winter 1993.

U.S. Bureau of Transportation Statistics. 1997. *National Transportation Statistics.* Washington, D.C.

U.S. Department of Transportation, Federal Transit Administration. December 1992. *Cashing Out Employer-Paid Parking.* Final Report. Washington, D.C.

Appendices

Appendix A

Estimating Emissions from Urban Transportation

Existing Activity Estimates

Modes Considered

Passenger Transportation

Private Automobiles

By all accounts, private automobiles overwhelmingly dominate passenger transportation modes. The term "private automobile" is generally used to describe passenger cars and light-duty trucks that are used for personal purposes. With the growing personal use of pick-up trucks, minivans and sport-utility vehicles, it is becoming increasingly difficult to determine the proportion of vehicles used for personal transportation and the proportion used for freight transportation.

Statistics Canada provides figures on registered vehicles. According to the figures, there were approximately 13.2 million passenger automobiles (excluding light-duty trucks) registered in Canada in 1996. Unfortunately, the Statistics Canada figures do not distinguish between light-duty trucks and heavy-duty trucks. According to Transport Canada,[1] light-duty trucks make up about 80% of total truck registrations. These light-duty trucks include pick-up trucks, minivans and sport-utility vehicles used primarily for private passenger travel. It is estimated that light-duty trucks are used for such travel about 80% of the time. Taking into account the estimated distributions between light-duty and heavy-duty trucks, the total number of light-duty trucks was 2.9 million in 1996.

Surface Bus

Surface buses are used for both urban and intercity travel. In 1995, there were about 43,500 buses in Canada. Of these 43,500 buses, about 1,200 were used for scheduled intercity trips, 2,700 for charter services, 26,500 for school transportation and 13,100 for urban transit. In terms of vehicle-kilometres of travel, urban transit accounted for the largest portion followed by school buses.[2]

This study focuses primarily on urban transit services and school bus services, since the proportion of intercity and charter trips made within urban areas is relatively small.

Rapid Transit

Rapid transit for the purposes of this study is defined as all urban modes of rapid transit that are powered by electricity. Based on this definition, the Ottawa Transitway, which uses diesel buses, would fall under the surface bus category even though it is functionally a rapid transit mode.

Rapid transit accounts for a significant proportion of the total transit passenger-kilometres in Montreal, Toronto and Vancouver.

---

[1] Transport Canada, *Transportation in Canada* — 1996, Annual Report (Ottawa, 1997).

[2] Ibid., Table 9-3.

Passenger Rail

The distinction between urban and non-urban categories of passenger rail is based on the type of service provided. The GO Transit and STCUM commuter rail journeys in the Toronto and Montreal urban regions are classified as urban trips, whereas VIA Rail journeys are classified as non-urban trips (i.e., inter-urban). No attempt has been made to separate out those portions of VIA Rail trips made in urban areas.

Freight Transportation

Heavy-Duty Trucks

The majority of road freight transportation is carried out using heavy-duty diesel trucks. According to Environment Canada statistics, there are approximately 150,000 heavy-duty gasoline vehicles in Canada, which are used for a total of 1.95 billion vehicle-kilometres of travel.[3] By comparison, it is estimated that there are about 373,000 heavy-duty diesel trucks, which are used for 26.8 billion vehicle-kilometres of travel. The primary difference between heavy-duty gasoline and diesel trucks is that diesel trucks travel much further on average. Heavy-duty trucks also account for a significantly higher portion of the total road freight tonne-kilometres.

Light-Duty Trucks

As discussed above, the use of light-duty trucks for commercial/freight purposes is becoming overshadowed by their use as private automobiles. Nevertheless, light-duty trucks are still used extensively for goods movement within urban areas and for courier services. It is assumed that about 20% of all light-duty trucks are used for commercial purposes.

Commercial light-duty trucks may be gasoline or diesel powered; however, the majority of diesel powered light-duty trucks would be used for commercial purposes.

Defining Urban Transportation

For bus, rail and rapid transit modes, it is relatively straightforward to distinguish between urban transit and intercity or non-urban transit, since statistics are available for each of the individual types of carriers. Conversely, distinguishing between urban and non-urban travel for auto and freight modes is highly subjective and highly dependent on the definition of urban travel that is used. Essentially, there are three categories of travel in Canada:

- trips made entirely within an urban area (where urban areas are defined as Census Metropolitan Areas [CMAs]);
- intercity trips (usually defined as trips greater than 50 kilometres or trips between two urban areas); and
- non-urban trips (which may include trips made in towns and villages).

[3] Environment Canada, *Trends in Canada's Greenhouse Gas Emissions, 1990-1995.* (Ottawa, April 1997), p. 22.

There is no accepted standard for defining urban auto travel, largely due to the scarcity of detailed data on urban travel activity. For the purposes of this study, urban auto travel is defined as any auto travel made by a person residing in an urban area (see page 10 for the definition used for urban areas). This definition was chosen largely because it reflects the types of travel that could be influenced by the policies explored in this study. For example, a vehicle registration fee would affect the behaviour of an urban auto owner, regardless of where that owner is travelling. However, some instruments, such as parking policies, would primarily affect travel within urban areas.

Developing a definition of urban freight movement is difficult given the level of data that is available (Statistics Canada does not provide data on trucking activity by CMA). Two basic approaches were explored in this study.

The first approach assumes that about 20% of diesel freight activity takes place within urban areas. This is based on the estimate that for a trip between two large urban centres about 500 kilometres apart (e.g., Toronto and Montreal), the total distance travelled in the urban areas would be about 20%. For gasoline trucks, it was reasoned that the ratio of urban to non-urban travel would be similar to that for automobiles and closely related to population and economic activity. On this basis, about 56% of all activity for gasoline trucks would occur in urban areas.

The second approach assumes that urban truck-kilometres are roughly 10% of urban automobile-kilometres, based on the average commercial vehicle percentages at a number of screenlines in the three largest urban areas. This was the assumption used in the IBI Group Full Cost Pricing Study.[4] The former approach was adopted for this study, although CO_2 estimates for both approaches are provided on page 95.

Urban Transportation Activity and CO_2 Estimates

Urban Passenger Transportation Activity

For the purposes of this study, CMAs have been used as the basis for discussing and quantifying urban passenger transportation and emissions. Exhibit A.1 provides a breakdown of the demographic data and transportation data for each of the 25 CMAs in Canada, as well as for Canada in total. Figures are shown here for 1995. Both the road modes and transit modes are shown.

As shown in Exhibit A.1, about 62% of the total Canadian population resides in one of the 25 CMAs. About 54% of the total Canadian population resides in the 13 largest CMAs.[5] The percentages of urban travel activity vary by mode. By definition, the proportion of automobile activity falling in the urban category is basically the same as the population distributions. For transit modes, a greater amount of travel occurs in urban areas.

---

4 IBI Group, *Full Cost Transportation and Cost Based Pricing Strategies* (Toronto: Transportation and Climate Change Collaborative, November 1995).

5 The top 13 CMAs in declining order of population are Toronto, Montreal, Vancouver, Ottawa-Hull, Edmonton, Calgary, Quebec City, Winnipeg, Hamilton, London, Kitchener, St. Catharines-Niagara, and Halifax.

In estimating CO_2 emissions, we have based the definition of urban transportation on the 13 largest CMAs. For all passenger transportation modes (excluding air and marine), it can be concluded that about 57% of annual passenger-kilometres is due to urban travel in Canada's 13 largest CMAs (which is our definition of "urban travel"). It is interesting to compare this estimate with other sources and approaches. For example, Transport Canada categorizes travel by cars and light-duty trucks according to facility type (e.g., highways versus the rest) and uses this as a rough guide for breaking out urban and non-urban travel. Transport Canada, in its internal documents, estimates urban car/light-duty truck travel at about 58% of the total Canadian passenger-kilometres and intercity travel at 42%.[6] The Royal Commission on National Passenger Transportation, in its 1992 series, assumed that approximately two-thirds of all road passenger-kilometres in Canada consisted of intercity travel, with the remaining one-third consisting of urban travel. By these definitions, intercity travel would include many trips that are made in non-urban areas, but are not actually intercity trips.

Exhibit A.2 outlines the development of urban passenger transportation activity and CO_2 emissions for the 13 largest CMAs. As shown, for road modes, urban transportation currently accounts for about 56% of all CO_2 emissions in Canada. Due to data limitations, a breakdown of CO_2 emissions by urban transit modes for all of Canada has not been shown. However, based on figures for all GHGs as shown in Exhibit 2.5 of the main report, urban transit is responsible for the majority of GHG emissions from transit.

Urban Freight Transportation

Urban freight transportation activity and emissions are derived by applying various factors to the total Canada-wide estimates. Exhibit A.3 outlines total freight activity and CO_2 emissions. Estimates of vehicle-kilometres were derived from vehicle stock and average distances travelled for the various vehicle types as reported by Environment Canada.[7] Freight tonne-kilometres were estimated by applying appropriate load factors based largely on judgment. The tonne-kilometres shown are for illustration purposes only and are not used in the calculation of emissions. CO_2 emissions for freight transportation modes are calculated by applying appropriate factors to the vehicle-kilometre estimates.

---

[6] J. Lawson, *Canada's Commitment on Greenhouse Gas Emissions under the Kyoto Protocol and the Potential for Reductions in Transport,* presentation to the Canadian Transportation Research Forum 33rd Annual Conference, Edmonton, Alberta, May 25-28, 1998.

[7] Environment Canada, *Trends in Canada's Greenhouse Gas Emissions, 1990-1995* (Ottawa, April 1997).

Exhibit A.1 Urban Passenger Transportation Activity

	Demographic Data		Annual Vehicle-km (Billions)				Annual Passenger-km (Billions)				
	Population	Total Households	Autos and Light Trucks	Surface Bus	Rapid Transit	Passenger Rail	Autos and Light Trucks	Surface Bus	Rapid Transit	Passenger Rail	Total
CMA											
Toronto	4,232,905	1,488,370	40	0.150	0.078	0.002	60	2.46	2.150	1.934	67
Montreal	3,287,645	1,341,270	32	0.121	0.065	0.004	48	1.93	1.947	0.577	53
Vancouver	1,813,935	692,960	14	0.062	0.024	0.001	22	1.85	0.714	0.053	24
Ottawa-Hull	1,000,940	385,145	10	0.040			16	0.65			16
Edmonton	845,230	320,065	11	0.032			17	0.51			18
Calgary	815,985	305,310	11	0.031			16	0.49			17
Quebec City	663,885	275,930	6.6	0.022			10	0.35			10
Winnipeg	660,055	261,915	5.7	0.025			8.5	0.39			8.9
Hamilton	617,815	235,605	6.3	0.012			9.5	0.19			9.7
London	393,900	156,015	4.2	0.010			6.3	0.15			6.4
Kitchener	379,350	140,460	3.8	0.006			5.7	0.09			5.8
St. Catharines-Niagara	367,790	144,505	3.9	0.004			5.8	0.06			5.9
Halifax	329,750	127,485	3.1	0.007			4.5	0.12			4.7
Subtotal (Top 13 CMAs)	**15,409,185**	**5,875,035**	**153**	**0.520**	**0.166**	**0.007**	**229**	**9.251**	**4.81**	**2.56**	**245**
Top 13 (%)	**54%**	**54%**	**56%**	**73%**		**100%**	**56%**	**71%**		**63%**	**57%**
Victoria	300,035	129,350	2.7	0.011			4.0	0.17			4.2
Windsor	275,745	105,795	2.8	0.004			4.3	0.06			4.3
Oshawa	266,585	93,715	2.5	0.003			3.8	0.04			3.8
Saskatoon	216,445	84,540	1.0	0.005			1.4	0.08			1.5
Regina	191,485	74,695	0.9	0.004			1.3	0.07			1.3
St. John's	172,090	60,295	1.4	0.002			2.1	0.04			2.1
Sudbury	158,935	61,940	1.7	0.003			2.5	0.04			2.5
Chicoutimi-Jonquière	158,865	59,935	1.4	0.000			2.2	0.00			2.2
Sherbrooke	144,575	60,855	1.5	0.004			2.2	0.07			2.2
Trois-Rivières	137,700	57,665	1.4	0.000			2.1	0.00			2.1
Thunder Bay	124,325	48,885	1.3	0.003			2.0	0.05			2.0
Saint John	124,215	47,055	1.1	0.002			1.6	0.03			1.6
Subtotal (Remaining 12)	**2,271,000**	**884,725**	**20**	**0.041**	**0.000**	**0.000**	**29**	**0.656**	**0.00**	**0.00**	**30**
Remaining 12 (%)	**8%**	**8%**	**7%**	**6%**	**0%**	**0%**	**7%**	**5%**	**0%**	**0%**	**7%**
All 25 CMAs	**17,680,185**	**6,759,760**	**172**	**0.561**	**0.166**	**0.007**	**258**	**9.91**	**4.81**	**2.56**	**275**
Urban Canada (%)[a]	**62%**	**62%**	**64%**	**79%**	**100%**	**100%**	**64%**	**76%**	**100%**	**63%**	**64%**
Rest of Canada	**10,847,940**	**4,060,290**	**99**	**0.153**	**nil**		**148**	**3.20**	**nil**	**1.50**	**153**
CANADA	**28,528,125**	**10,820,050**	**271**	**0.71**	**0.17**	**0.007**	**406**	**13.1**	**4.81**	**4.06**	**428**

Note:

[a] For autos, the percent urban is the same for both vehicle kilometres and passenger-kilometres, since the same load factors are used for both urban and non urban trips. Based on the methodology, it is not possible to determine what portion of urban dwellers' trips are intercity trips.

Exhibit A.2 Passenger Transportation Activity and CO_2 Emissions *(for top 13 CMAs)*

	Automobiles and Light Trucks				Urban Transit			Total
	LDGA	LDGT	MC	LDDA	Bus	Rapid Transit	Passenger	Passenger
Baseline Data (1990)								
Vehicle stock (000s)	5,972	1,542	189	65	—	—	—	
Annual km per vehicle	17,600	16,500	2,800	17,600	—	—	—	
Fuel consumption ratio (litres/100 km)	11.60	15.50	7.20	14.60	—	—	—	
CO_2 factor (g/litre)	2,360	2,360	2,360	2,360	—	—	—	
CO_2 factor (g/veh-km) (transit: g/pass-km)	274	366	170	345	81	22	47	
Veh-km (billions)	105	25	0.5	1.1	0.57	0.18	0.01	
Pass-km	164	32	0.5	1.8	9.94	5.03	2.51	215
CO_2 Emissions (kt) — Urban (13 CMAs)	**28,701**	**9,307**	**90**	**395**	**806**	**111**	**118**	**39,527**
CO_2 Emissions (kt) — Canada	**51,767**	**16,936**	**164**	**712**				
% Urban	**55%**	**55%**	**55%**	**55%**				
Baseline Data (1995)								
Vehicle stock (000s)	6,599	1,752	193	67	—	—	—	
Annual km per vehicle	18,300	17,100	3,000	18,300	—	—	—	
Fuel consumption ratio (litres/100 km)	10.60	14.30	7.20	14.60	—	—	—	
CO_2 factor (g/litre)	2,360	2,360	2,360	2,360	—	—	—	
CO_2 factor (g/veh-km) (transit: g/pass-km)	250	337	170	345	81	22	47	
Veh-km (billions)	121	30	0.6	1.2	0.56	0.17	0.01	
Pass-km	188	38	0.6	1.9	9.91	4.81	2.56	246
CO_2 Emissions (kt) — Urban (13 CMAs)	**30,220**	**10,140**	**99**	**420**	**803**	**106**	**121**	**41,907**
CO_2 Emissions (kt) — Canada	**53,584**	**18,129**	**177**	**744**	—	—	—	—
% Urban	**56%**	**56%**	**56%**	**56%**				

Notes:

LDGA = light-duty gasoline automobile
LDGT = light-duty gasoline truck
MC = motorcycle
LDDA = light-duty diesel automobile

Exhibit A3 Freight Transportation Activity and CO_2 Emissions

Geographic Definition	1990 HDDV	1990 HDGV	1990 LDDT	1990 LDGT[a]	1990 Rail	1990 Total	1995 HDDV	1995 HDGV	1995 LDDT	1995 LDGT[a]	1995 Rail	1995 Total
All of Canada												
Stock	250,000	140,000	77,000	651,000			373,000	150,000	91,000	790,000		
Distance/vehicle	82,869	13,000	23,000	17,000			72,000	13,000	23,000	17,000		
Fuel consumption ratio	40.0	40.1	18.6	16.4			39.0	40.1	18.6	14.3		
Veh-km (billions)[b]	20.717	1.8	1.8	11.1		35.4	26.856	2.0	2.1	13.4		44.3
Assumed load factor	8.0	8.0	1.0	0.5		17.5	8.0	8.0	1.0	0.5		17.5
Tonne-km (billions)[c]	165.7	14.6	1.8	5.5	282	470	214.8	15.6	2.1	6.7	282	521
CO_2 factor[b] (g/litre)	2,730	2,360	2,730	2,360			2,730	2,360	2,730	2,360		
CO_2 factor (g/veh-km)	1,092	946	508	387			1,065	946	508	337		
Total CO_2 (kt)	22,623	1,722	899	4,281			28,594	1,845	1,063	4,532		
Urban Canada (Method 1)												
Urban % of truck veh-km	20%	56%	56%	56%	—		20%	56%	56%	56%	—	
Veh-km (billions)	4.1	1.0	1.0	6.2	—		5.4	1.1	1.2	7.5	—	
Tonne-km (billions)	33.1	8.2	1.0	3.1	—		43.0	8.7	1.2	3.8	—	
Total CO_2 (kt)	4,525	965	504	2,397			5,719	1,033	595	2,538		
Urban Canada (Method 2)												
Veh-km (billions)[d]	3.0	1.7	0.9	7.7	—		3.5	1.4	0.9	7.4	—	
Tonne-km (billions)	23.6	13.2	0.9	3.8	—		28.0	11.3	0.9	3.7	—	
Total CO_2 (kt)	3,222	1,564	461	2,972			3,733	1,334	434	2,506		
Modal Share of Tonne-km (All Canada)	32%	3%	0%	1%	54%	90%	41%	3%	0%	1%	54%	100%

Notes:

HDDV = heavy-duty diesel vehicle
HDGV = heavy-duty gasoline vehicle
LDDT = light-duty diesel truck
LDGT = light-duty gasoline truck

[a] Twenty percent of LDGT vehicle-km is assumed to be for commercial or freight purposes.
[b] Based on information from Environment Canada, *Trends in Canada's Greenhouse Gas Emissions* (Ottawa, 1997).
[c] Rail tonne-km were obtained from Transport Canada reports.
[d] Assuming truck-km are 10% of auto-km.

Future Forecasts

Exhibit A.4 provides a summary of the existing and future transportation activity and CO_2 emissions for urban passenger and freight modes, as defined above. Estimates of future activity and emissions are highly dependent on the estimated growth rates for the various components used to develop the emissions estimates. Growth rates were required for vehicle stock, annual kilometres of travel per vehicle and fuel efficiency. In general, growth rates were adopted from Natural Resources Canada (NRCan) projections. NRCan's report *Canada's Energy Outlook* provides a good overview of the assumptions used to develop future projections for transportation activity and emissions.[8]

An important observation from the growth factors is an anticipated continuing shift from automobiles to light-duty trucks, minivans and sport-utility vehicles. This has a significant impact on emissions since these vehicles are more fuel intensive than smaller cars.

As shown, CO_2 emissions from passenger transportation (including public transportation modes) are projected to increase by 15% over 1990 levels by 2010. CO_2 emissions from freight transportation are expected to increase by 54% over 1990 levels by 2010. The increase in CO_2 emissions from freight transportation is largely due to the rapidly growing reliance on heavy-duty diesel freight for goods movement.

For gasoline vehicles (not shown), emissions are expected to increase by 18% between 1990 and 2010. For diesel sources, the increases are estimated at 56%. These figures are consistent with other sources. The overall 1990 to 2010 increase for all road vehicles and transit vehicles is estimated at 22%, which is slightly lower than the 26% estimated by NRCan. However, urban transportation has a lower percentage of freight transportation, which is the fastest growing transportation sector.

[8] Natural Resources Canada, *Canada's Energy Outlook* 1990-2020 (Ottawa, April 1997).

Development of Future Activity and Emissions *(for top 13 CMAs)*

	Automobiles and Light Trucks				Urban Transit			Road Freight				Total	Total	Total
	LDGA	LDGT	MC	LDDA	Bus	Rapid Transit	Pass. Rail	HDDV	HDGV	LDDT	LDGT	Passenger	Freight	
Baseline Data (1990)														
Vehicle stock (000s)	5,972	1,542	189	65	—	—	—	—	—	—	—			
Annual km per vehicle	17,600	16,500	2,800	17,600	—	—	—	—	—	—	—			
Fuel consumption ratio (litres/100 km)	11.60	15.50	7.20	14.60	—	—	—	40.00	40.10	18.60	16.39			
CO_2 factor (g/litre)	2,360	2,360	2,360	2,730	—	—	—	2,730	2,360	2,730	2,360			
CO_2 factor (g/veh-km) (transit: g/pass-km)	274	366	170	399	81	22	47	1,092	946	508	387			
Veh-km (billions)	105	25	0.5	1.1	0.57	0.18	0.01	4.1	1.0	1.0	6.2			
Pass-km/tonne-km	164	32	0.5	1.8	9.94	5.03	2.51	33.1	8.2	1.0	3.1			
CO_2 Emissions (kt)	**28,701**	**9,307**	**90**	**457**	**806**	**111**	**118**	**4,525**	**965**	**504**	**2,397**	**39,589**	**8,390**	**47,979**
Baseline Data (1995)														
Vehicle stock (000s)	6,599	1,752	193	67	—	—	—	—	—	—	—			
Annual km per vehicle	18,300	17,100	3,000	18,300	—	—	—	—	—	—	—			
Fuel consumption ratio (litres/100 km)	10.60	14.30	7.20	14.60	—	—	—	39.00	40.10	18.60	14.30			
CO_2 factor (g/litre)	2,360	2,360	2,360	2,730		—	—	2,730	2,360	2,730	2,360			
CO_2 factor (g/veh-km) (transit: g/pass-km)	250	337	170	399	81	22	47	1,065	946	508	337			
Veh-km (billions)	121	30	0.6	1.2	0.56	0.17	0.01	5.4	1.1	1.2	7.5			
Pass-km/tonne-km	188	38	0.6	1.9	9.91	4.81	2.56	43.0	8.7	1.2	3.8			
CO_2 Emissions (kt)	30,220	10,140	99	486	803	106	121	5,719	1,033	595	2,538	41,973	9,885	51,858
Baseline Growth Factors (1995-2010)														
Vehicle stock (000s)	0.5%	2.5%	0.5%	0.5%	—	—	—	1.8%	2.5%	2.5%	2.5%			
Annual km per vehicle	0.1%	-0.04%	0.1%	0.1%	—	—	—	0.25%		-0.04%	-0.04%			
Fuel consumption ratio (litres/100 km)	-0.63%	-0.45%	-0.63%	-0.63%	-0.4%	—	—	-0.45%	-0.45%	-0.45%	-0.45%			
Load factor improvement	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%			
Baseline Data (2010)														
Vehicle stock (000s)	7,122	2,552	208	72	—	—	—	—	—	—	—			
Annual km per vehicle	18,639	16,995	3,056	18,639	—	—	—	—	—	—	—			
Fuel consumption ratio (litres/100 km)	9.65	13.4	6.6	13.3	—	—	—	36.4	37.5	17.4	13.4			
CO_2 Factor (g/L)	2,360	2,360	2,360	2,730	—	—	—	2,730	2,360	2,730	2,360			
CO_2 factor (g/veh-km) (transit: g/pass-km)	228	315	155	363	73	20	36	995	884	475	315			
Veh-km (billions)	132.74	43	0.6	1.3	0.67	0.20	0.01	7.3	1.6	1.7	10.9			
Pass-km/tonne-km	207	55	1	2	11.9	5.8	3.2	58.3	12.6	1.7	5.4			
CO_2 Emissions (kt)	**30,218**	**13,678**	**98**	**486**	**869**	**117**	**114**	**7,251**	**1,398**	**805**	**3,433**	45,581	12,887	58,468
% Change from 1990	**5%**	**47%**	**9%**	**6%**	**8%**	**5%**	**-3%**	**60%**	**45%**	**60%**	**43%**	15%	54%	22%

Notes:

LDGA = light-duty gasoline automobile
LDGT = light-duty gasoline truck
MC = motorcycle
LDDA = light-duty diesel automobile

HDDV = heavy-duty diesel vehicle
HDGV = heavy-duty gasoline vehicle
LDDT = light-duty diesel truck

Appendix B

Estimating the Impacts of Individual Options to Reduce CO_2

General Approach and Assumptions

Overview

The impacts of alternative policy options were estimated for CO_2 only. The general approach involved calculating the CO_2 emissions for 1990 and for the business-as-usual 2010 horizon year. The CO_2 levels were then calculated for the 2010 horizon year assuming the specific policies had been implemented, and then compared with both the 1990 levels and the 2010 baseline levels.

The tables following this text provide details of the CO_2 reductions for each of the scenarios. The impacts of the specific policy are shown at the bottom of the table, and the baseline data are shown at the top. The baseline data are repeated for all scenarios to allow for easy comparisons.

The impacts are calculated for each type of vehicle (based on Environment Canada definitions) and then aggregated into passenger transportation modes and freight modes. Passenger transportation modes include both private road modes and urban transit modes, whereas freight modes include road freight only. Aviation, marine and rail freight modes are not included in the totals since these are primarily non-urban modes.

Assumptions

In estimating the impacts of the various policy options, several assumptions were made. A list of the major assumptions is provided below.

- Where a specific policy measure (e.g., fuel taxes, parking pricing) affects vehicle-kilometres of travel, adjustments were made to account for the fact that some activity will shift to other modes. For the purposes of this study, it was generally assumed that 25% of auto vehicle-kilometre reductions would come from modal shifts to transit, while the remaining 75% would be due to reduced numbers of trips, reduced trip lengths, modal shifts to non-motorized modes and higher load factors.

- For diesel fuel price increases, the impacts were examined for urban freight only. In fact, a diesel fuel price increase would be applied unilaterally and would affect both urban and intercity travel. A further assumption regarding diesel fuel tax was that there would be no emissions impacts from redistributing freight tonne-kilometres to other modes. While some of the reductions in CO_2 would be attributable to increased load factors and reduced trips, there would also be some shifts to rail and marine modes. In practice, the reduction in urban road freight vehicle-kilometres might be offset by the fact that there would be more local freight activity by trucks.

- For Corporate Average Fuel Efficiency/Consumption (CAFE/CAFC) standards, the fuel efficiency improvements apply to new vehicles only. For these scenarios, we have accounted for the ramping effects of the policy option, which occur because it takes time for all vehicles to be replaced. Based on other literature, it was assumed that roughly 8% of the total vehicle stock is replaced on an annual basis. A further adjustment for the CAFE/CAFC options is the take-back effect that results from more fuel efficient vehicles — people may tend to drive more if they have to pay for less fuel. As discussed in the main report, the take-back effect has been estimated at approximately one-third.

- There is also a ramping effect for the technology improvements and shifts in vehicle fleet mix due to fuel pricing increases. These ramping effects have been incorporated into the assessment of impacts.

- For the feebate options, fuel efficiency improvements apply to new vehicles only. Since the program would be implemented starting in 2005, it was assumed that roughly 50% of all vehicles in 2010 would have been purchased under a feebate program (assuming 8% replacement per year for six years). The reductions for new vehicle fuel economy described in Exhibit 3.8 were therefore reduced by a factor of 0.5.

- The impacts of parking pricing were assessed separately for trips to urban areas and for trips to the three largest downtown areas. Based on data from the Toronto *Transportation Tomorrow Survey*,[1] it can be concluded that about 5% of all daily auto trips have destinations in the downtown Toronto area, and demand would be highly elastic to parking prices. For the purpose of this study, this ratio of 5% was applied to Montreal and Vancouver as well. It was also assumed that parking price increases would be applied to all public and commercial parking in the Census Metropolitan Areas. A large portion of this parking is free, which makes it difficult to determine an appropriate elasticity value. The estimates presented in this report should be considered as broad estimates only.

- For the road pricing option, an estimate of the proportion of travel on limited-access expressways was derived from information on the total length of expressways in the Greater Toronto Area (506 km) and average daily traffic volumes. It was estimated that 20% of all auto travel in urban areas takes place on limited-access expressways. Ten percent was estimated to take place in the peak periods, with the remainder taking place in the off-peak period.

[1] University of Toronto Joint Program in Transportation, Data Management Group, *The Transportation Tomorrow Survey* (Toronto, 1996).

For Exhibits B.1-B.10, the following notes apply:

FCR = fuel consumption ratio
HDDV = heavy-duty diesel vehicle
HDGV = heavy-duty gasoline vehicle
LDDA = light-duty diesel automobile
LDDT = light-duty diesel truck
LDGA = light-duty gasoline automobile
LDGT = light-duty gasoline truck
MC = motorcycle

Exhibit 8.1 Examination of Individual Options, Gasoline Tax (Canada only) *(for top 13 CMAs)*

	Automobiles and Light Trucks				Urban Transit				Road Freight			Total	Total	Total
	LDGA	LDGT	MC	LDDA	Bus	Rapid Transit	Pass. Rail	HDDV	HDGV	LDDT	LDGT	Passenger	Freight	
Baseline Data (1990)														
Vehicle stock (000s)	5,972	1,542	189	65	—	—	—	—	—	—	—			
Annual km per vehicle	17,600	16,500	2,800	17,600	—	—	—	—	—	—	—			
Fuel consumption ratio (L/100 km)	11.60	15.50	7.20	14.60	—	—	—	40.00	40.10	18.60	16.39			
CO_2 factor (g/L)	2,360	2,360	2,360	2,730	—	—	—	2,730	2,360	2,730	2,360			
CO_2 factor (g/veh-km) (transit: g/pass-km)	274	366	170	399	81	22	47	1,092	946	508	387			
Veh-km (billions)	105	25	0.5	1.1	0.57	0.18	0.01	4.1	1.0	1.0	6.2			
Pass-km/tonne-km	164	32	0.5	1.8	9.94	5.03	2.51	33.1	8.2	1.0	3.1			
CO_2 Emissions (kt)	**28,701**	**9,307**	**90**	**457**	**806**	**111**	**118**	**4,525**	**965**	**504**	**2,397**	39,589	8,390	47,979
Baseline Data (2010)														
Vehicle stock (000s)	7,122	2,552	208	72	—	—	—	—	—	—	—			
Annual km per vehicle	18,639	16,995	3,056	18,639	—	—	—	—	—	—	—			
Fuel consumption ratio (L/100 km)	9.65	13.4	6.6	13.3	—	—	—	36.4	37.5	17.4	13.4			
CO_2 factor (g/L)	2,360	2,360	2,360	2,730	—	—	—	2,730	2,360	2,730	2,360			
CO_2 factor (g/veh-km) (transit: g/pass-km)	228	315	155	363	73	20	36	995	884	475	315			
Veh-km (billions)	132.74	43	0.6	1.3	0.67	0.20	0.01	7.3	1.6	1.7	10.9			
Pass-km/tonne-km	207	55	1	2	11.9	5.8	3.2	58.3	12.6	1.7	5.4			
CO_2 Emissions (kt)	**30,218**	**13,678**	**98**	**486**	**869**	**117**	**114**	**7,251**	**1,398**	**805**	**3,433**	45,581	12,887	58,468
% Change from 1990	5%	47%	9%	6%	8%	5%	-3%	60%	45%	60%	43%	15%	54%	22%
Scenario 1A — Gasoline Tax (3 cents/litre annually — Canada only)														
Annual increase (cents/yr)	$0.03	$0.03	$0.03						$0.03		$0.03			
Assumed base price	$0.55	$0.55	$0.55						$0.55		$0.55			
Elasticity (price vs. veh-km)	-0.15	-0.15	-0.15						0.15		0.15			
Elasticity (price vs. new vehicle FCR)	-0.15	-0.15	-0.15						-0.15		-0.15			
New Veh-km	121.9	39.8	0.6						1.5		10.0			
Pass-km shifted to transit (25% of reductions)	4.2	1.1	0.0						0.3		0.1			
New pass-km					14.96	7.33	4.00							
New FCR	9.30	12.9	6.3						36.1		12.9			
CO_2 factor (g/veh-km) (transit: g/pass-km)	219.5	304.0	149.1		73	20	36		852.6		304.0			
New CO_2	**26,747**	**12,107**	**87**	**486**	**1,092**	**147**	**144**	**7,251**	**1,237**	**805**	**3,039**	**40,809**	**12,332**	**53,141**
% change from 2010 baseline	-11%	-11%	-11%	0%	26%	26%	26%	0%	-11%	0%	-11%	-10%	-4%	-9%
% Change from 1990	-7%	30%	-3%	6%	36%	32%	22%	60%	28%	60%	27%	3%	47%	11%
Scenario 2A — Gasoline Tax (Kyoto-based — Canada only)														
Annual increase (cents/yr)	$0.054	$0.054	$0.054						$0.05		$0.05			
Assumed base price	$0.55	$0.55	$0.55						$0.55		$0.55			
Elasticity (price vs. veh-km)	-0.15	0.15	-0.15						0.15		-0.15			
Elasticity (price vs. new vehicle FCR)	-0.15	-0.15	-0.15						-0.15		-0.15			
New veh-km	113.2	37.0	0.5						1.3		9.3			
Pass-km shifted to transit (25% of reductions)	7.6	2.0	0.0						0.5		0.2			
New pass-km					17.40	8.53	4.65							
New FCR	9.02	12.5	6.1						35.0		12.5			
CO_2 factor (g/veh-km) (transit: g/pass-km)	212.9	295.0	144.6		73	20	36		827.1		295.0			
New CO_2	**24,098**	**10,908**	**78**	**486**	**1,271**	**171**	**167**	**7,251**	**1,115**	**805**	**2,738**	**37,179**	**11,909**	**49,087**
% change from 2010 baseline	-20%	-20%	-20%	0%	46%	46%	46%	0%	-20%	0%	-20%	-18%	-8%	-16%
% Change from 1990	-16%	17%	-13%	6%	58%	54%	42%	60%	16%	60%	14%	-6%	42%	2%

Exhibit B.2 **Examination of Individual Options, Gasoline Tax (North America-wide)** *(for top 13 CMAs)*

	Automobiles and Light Trucks				Urban Transit			Road Freight				Total Passenger	Total Freight	Total
	LDGA	LDGT	MC	LDDA	Bus	Rapid Transit	Pass. Rail	HDDV	HDGV	LDDT	LDGT			
Baseline Data (1990)														
Vehicle stock (000s)	5,972	1,542	189	65	—	—	—	—	—	—	—			
Annual km per vehicle	17,600	16,500	2,800	17,600	—	—	—	—	—	—	—			
Fuel consumption ratio (L/100 km)	11.60	15.50	7.20	14.60	—	—	—	40.00	40.10	18.60	16.39			
CO_2 factor (g/L)	2,360	2,360	2,360	2,730	—	—	—	2,730	2,360	2,730	2,360			
CO_2 factor (g/veh-km) (transit: g/pass-km)	274	366	170	399	81	22	47	1,092	946	508	387			
Veh-km (billions)	105	25	0.5	1.1	0.57	0.18	0.01	4.1	1.0	1.0	6.2			
Pass-km/tonne-km	164	32	0.5	1.8	9.94	5.03	2.51	33.1	8.2	1.0	3.1			
CO_2 Emissions (kt)	**28,701**	**9,307**	**90**	**457**	**806**	**111**	**118**	**4,525**	**965**	**504**	**2,397**	39,589	8,390	47,979
Baseline Data (2010)														
Vehicle stock (000s)	7,122	2,552	208	72	—	—	—	—	—	—	—			
Annual km per vehicle	18,639	16,995	3,056	18,639	—	—	—	—	—	—	—			
Fuel consumption ratio (L/100 km)	9.65	13.4	6.6	13.3	—	—	—	36.4	37.5	17.4	13.4			
CO_2 factor (g/L)	2,360	2,360	2,360	2,730	—	—	—	2,730	2,360	2,730	2,360			
CO_2 factor (g/veh-km) (transit: g/pass-km)	228	315	155	363	73	20	36	995	884	475	315			
Veh-km (billions)	132.74	43	0.6	1.3	0.67	0.20	0.01	7.3	1.6	1.7	10.9			
Pass-km/tonne-km	207	55	1	2	11.9	5.8	3.2	58.3	12.6	1.7	5.4			
CO_2 Emissions (kt)	**30,218**	**13,678**	**98**	**486**	**869**	**117**	**114**	**7,251**	**1,398**	**805**	**3,433**	45,581	12,887	58,468
% Change from 1990	**5%**	**47%**	**9%**	**6%**	**8%**	**5%**	**-3%**	**60%**	**45%**	**60%**	**43%**	15%	54%	22%
Scenario 1B — Gasoline Tax (3 cents/litre annually — North America-wide)														
Annual increase (cents/yr)	$0.03	$0.03	$0.03						$0.03		$0.03			
Assumed base price	$0.55	$0.55	$0.55						$0.55		$0.55			
Elasticity (price vs. veh-km)	-0.15	-0.15	-0.15						-0.15		-0.15			
Elasticity (price vs. new vehicle FCR)	-0.40	-0.40	-0.40						-0.40		-0.40			
New veh-km	121.9	39.8	0.6						1.5		10.0			
Pass-km shifted to transit (25% of reductions)	4.2	1.1	0.0						0.3		0.1			
New pass-km					14.96	7.33	4.00							
New FCR	8.720	12.1	5.9						33.9		12.1			
CO_2 factor (g/veh-km) (transit: g/pass-km)	205.8	285.1	139.8		73	20	36		799.5		285.1			
New CO_2	**25,082**	**11,353**	**82**	**486**	**1,092**	**147**	**144**	**7,251**	**1,160**	**805**	**2,850**	38,385	12,066	50,452
% change from 2010 baseline	-17%	-17%	-17%	0%	26%	26%	26%	0%	-17%	0%	-17%	-16%	-6%	-14%
% Change from 1990	**-13%**	**22%**	**-9%**	**6%**	**36%**	**32%**	**22%**	**60%**	**20%**	**60%**	**19%**	-3%	44%	5%
Scenario 2B — Gasoline Tax (Kyoto-based — North America-wide)														
Annual increase (cents/yr)	$0.036	$0.036	$0.036						$0.036		$0.036			
Assumed base price	$0.55	$0.55	$0.55						$0.55		$0.55			
Elasticity (price vs. veh-km)	-0.15	-0.15	-0.15						-0.15		-0.15			
Elasticity (price vs. new vehicle FCR)	-0.40	-0.40	-0.40						-0.40		-0.40			
New veh-km	119.7	39.1	0.6						1.4		9.8			
Pass-km shifted to transit (25% of reductions)	5.1	1.3	0.0						0.3		0.1			
New pass-km					15.57	7.63	4.16							
New FCR	8.535	11.8	5.8						33.2		11.8			
CO_2 factor (g/veh-km) (transit: g/pass-km)	201.4	279.1	136.8		73	20	36		782.6		279.1			
New CO_2	**24,112**	**10,914**	**79**	**486**	**1,137**	**153**	**150**	**7,251**	**1,115**	**805**	**2,739**	37,029	11,911	48,940
% change from 2010 baseline	-20%	-20%	-20%	0%	31%	31%	31%	0%	-20%	0%	-20%	-19%	-8%	-16%
% Change from 1990	**-16%**	**17%**	**-13%**	**6%**	**41%**	**38%**	**27%**	**60%**	**16%**	**60%**	**14%**	-6.5%	42%	2%

Examination of Individual Options, Diesel Fuel Tax *(for top 13 CMAs)*

	Automobiles and Light Trucks				Urban Transit			Road Freight				Total	Total	Total
	LDGA	LDGT	MC	LDDA	Bus	Rapid Transit	Pass. Rail	HDDV	HDGV	LDDT	LDGT	Passenger	Freight	
Baseline Data (1990)														
Vehicle stock (000s)	5,972	1,542	189	65	—	—	—	—	—	—	—			
Annual km per vehicle	17,600	16,500	2,800	17,600	—	—	—	—	—	—	—			
Fuel consumption ratio (L/100 km)	11.60	15.50	7.20	14.60	—	—	—	40.00	40.10	18.60	16.39			
CO_2 factor (g/L)	2,360	2,360	2,360	2,730	—	—	—	2,730	2,360	2,730	2,360			
CO_2 factor (g/veh-km) (transit 10/23/98 g/pass-km)	274	366	170	399	81	22	47	1,092	946	508	387			
Veh-km (billions)	105	25	0.5	1.1	0.57	0.18	0.01	4.1	1.0	1.0	6.2			
Pass-km/tonne-km	164	32	0.5	1.8	9.94	5.03	2.51	33.1	8.2	1.0	3.1			
CO_2 Emissions (kt)	**28,701**	**9,307**	**90**	**457**	**806**	**111**	**118**	**4,525**	**965**	**504**	**2,397**	**39,589**	**8,390**	**47,979**
Baseline Data (2010)														
Vehicle stock (000s)	7,122	2,552	208	72	—	—	—	—	—	—	—			
Annual km per vehicle	18,639	16,995	3,056	18,639	—	—	—	—	—	—	—			
Fuel consumption ratio (L/100 km)	9.65	13.4	6.6	13.3	—	—	—	36.4	37.5	17.4	13.4			
CO_2 factor (g/L)	2,360	2,360	2,360	2,730	—	—	—	2,730	2,360	2,730	2,360			
CO_2 factor (g/veh-km) (transit: g/pass-km)	228	315	155	363	73	20	36	995	884	475	315			
Veh-km (billions)	132.74	43	0.6	1.3	0.67	0.20	0.01	7.3	1.6	1.7	10.9			
Pass-km/tonne-km	207	55	1	2	11.9	5.8	3.2	58.3	12.6	1.7	5.4			
CO_2 Emissions (kt)	**30,218**	**13,678**	**98**	**486**	**869**	**117**	**114**	**7,251**	**1,398**	**805**	**3,433**	**45,581**	**12,887**	**58,468**
% Change from 1990	5%	47%	9%	6%	8%	5%	-3%	60%	45%	60%	43%	15%	54%	22%
Diesel Fuel Tax (3 cents/litre annually)														
Annual increase (cents/yr)				$0.030				$0.030		$0.030				
Assumed base price				$0.50				$0.50		$0.50				
Elasticity (price vs. fuel consumption)				-0.20				-0.20		-0.20				
New CO_2	**30,218**	**13,678**	**98**	**427**	**869**	**117**	**114**	**6,381**	**1,398**	**708**	**3,433**	**45,522**	**11,920**	**57,443**
% change from 2010 baseline	0%	0%	0%	-12%	0%	0%	0%	-12%	0%	-12%	0%	0%	-8%	-2%
% Change from 1990	5%	47%	9%	-6%	8%	5%	-3%	41%	45%	41%	43%	15%	42%	20%

Examination of Individual Options, CAFC and CAFE *(for top 13 CMAs)*

	Automobiles and Light Trucks				Urban Transit			Road Freight				Total Passenger	Total Freight	Total
	LDGA	LDGT	MC	LDDA	Bus	Rapid Transit	Pass. Rail	HDDV	HDGV	LDDT	LDGT			
Baseline Data (1990)														
Vehicle stock (000s)	5,972	1,542	189	65	—	—	—	—	—	—	—			
Annual km per vehicle	17,600	16,500	2,800	17,600	—	—	—	—	—	—	—			
Fuel consumption ratio (L/100 km)	11.60	15.50	7.20	14.60	—	—	—	40.00	40.10	18.60	16.39			
CO_2 factor (g/L)	2,360	2,360	2,360	2,730	—	—	–	2,730	2,360	2,730	2,360			
CO_2 factor (g/veh-km) (transit: g/pass-km)	274	366	170	399	81	22	47	1,092	946	508	387			
Veh-km (billions)	105	25	0.5	1.1	0.57	0.18	0.01	4.1	1.0	1.0	6.2			
Pass-km/tonne-km	164	32	0.5	1.8	9.94	5.03	2.51	33.1	8.2	1.0	3.1			
CO_2 Emissions (kt)	**28,701**	**9,307**	**90**	**457**	**806**	**111**	**118**	**4,525**	**965**	**504**	**2,397**	**39,589**	**8,390**	**47,979**
Baseline Data (2010)														
Vehicle stock (000s)	7,122	2,552	208	72	—	—	—	—	—	—	—			
Annual km per vehicle	18,639	16,995	3,056	18,639	—	—	—	—	-	—	—			
Fuel consumption ratio (L/100 km)	9.65	13.4	6.6	13.3	—	—	—	36.4	37.5	17.4	13.4			
CO_2 factor (g/L)	2,360	2,360	2,360	2,730	—	—	—	2,730	2,360	2,730	2,360			
CO_2 factor (g/veh-km) (transit: g/pass-km)	228	315	155	363	73	20	36	995	884	475	315			
Veh-km (billions)	132.74	43	0.6	1.3	0.67	0.20	0.01	7.3	1.6	1.7	10.9			
Pass km/tonne-km	207	55	1	2	11.9	5.8	3.2	58.3	12.6	1.7	5.4			
CO_2 Emissions (kt)	**30,218**	**13,678**	**98**	**486**	**869**	**117**	**114**	**7,251**	**1,398**	**805**	**3,433**	45,581	12,887	58,468
% Change from 1990	5%	47%	9%	6%	8%	5%	-3%	60%	45%	60%	43%	15%	54%	22%
CAFC (1% annual improvement from 2005-2010) (Canada-wide)														
New fuel efficiency	9.5	13.2	6.4	13.1						17.2	13.2			
New CO_2	**29,730**	**13,525**	**97**	**478**	**869**	**117**	**114**	**7,251**	**1,398**	**796**	**3,395**	44,930	12,840	57,770
% change from 2010 baseline	-1.6%	-1.1%	-1.6	-1.6%	0.0%	0.0%	0.0%	0.0%	0.0%	-1.1%	-1.1%	-1.4%	-0.4%	-1.2%
% Change from 1990	**4%**	**45%**	**7%**	**5%**	**8%**	**5%**	**-3%**	**60%**	**45%**	**58%**	**42%**	**13%**	**53%**	**20%**
CAFE (2% annual improvement from 2005-2010) (North America-wide)														
New fuel efficiency	9.4	13.1	6.4	12.9						17.0	13.1			
New CO_2	**29,393**	**13,371**	**96**	**472**	**869**	**117**	**114**	**7,251**	**1,398**	**787**	**3,356**	44,433	12,792	57,225
% change from 2010 baseline	-2.7%	-2.2%	-2.7%	-2.7%	0.0%	0.0%	0.0%	0.0%	0.0%	-2.2%	-2.2%	-2.5%	-0.7%	-2.1%
% Change from 1990	**2%**	**44%**	**6%**	**3%**	**8%**	**5%**	**-3%**	**60%**	**45%**	**56%**	**40%**	**12%**	**52%**	**19%**

Exhibit 0.5 **Examination of Individual Options, Feebates (Canada only)** *(for top 13 CMAs)*

	Automobiles and Light Trucks				Urban Transit			Road Freight				Total	Total	Total
	LDGA	LDGT	MC	LDDA	Bus	Rapid Transit	Pass. Rail	HDDV	HDGV	LDDT	LDGT	Passenger	Freight	
Baseline Data (1990)														
Vehicle stock (000s)	5,972	1,542	189	65	—	—	—	—	—	—	—			
Annual km per vehicle	17,600	16,500	2,800	17,600	—	—	—	—	—	—	—			
Fuel consumption ratio (L/100 km)	11.60	15.50	7.20	14.60	—	—	—	40.00	40.10	18.60	16.39			
CO_2 factor (g/L)	2,360	2,360	2,360	2,730	—	—	—	2,730	2,360	2,730	2,360			
CO_2 factor (g/veh-km) (transit: g/pass-km)	274	366	170	399	81	22	47	1,092	946	508	387			
Veh-km (billions)	105	25	0.5	1.1	0.57	0.18	0.01	4.1	1.0	1.0	6.2			
Pass-km/tonne-km	164	32	0.5	1.8	9.94	5.03	2.51	33.1	8.2	1.0	3.1			
CO_2 Emissions (kt)	**28,701**	**9,307**	**90**	**457**	**806**	**111**	**118**	**4,525**	**965**	**504**	**2,397**	**39,589**	**8,390**	**47,979**
Baseline Data (2010)														
Vehicle stock (000s)	7,122	2,552	208	72	—	—	—	—	—	—	—			
Annual km per vehicle	18,639	16,995	3,056	18,639	—	—	—	—	—	—	—			
Fuel consumption ratio (L/100 km)	9.65	13.4	6.6	13.3	—	—	—	36.4	37.5	17.4	13.4			
CO_2 factor (g/L)	2,360	2,360	2,360	2,730	—	—	—	2,730	2,360	2,730	2,360			
CO_2 factor (g/veh-km) (transit: g/pass-km)	228	315	155	363	73	20	36	995	884	475	315			
Veh-km (billions)	132.74	43	0.6	1.3	0.67	0.20	0.01	7.3	1.6	1.7	10.9			
Pass-km/tonne-km	207	55	1	2	11.9	5.8	3.2	58.3	12.6	1.7	5.4			
CO_2 Emissions (kt)	30,218	13,678	98	486	869	117	114	7,251	1,398	805	3,433	45,581	12,887	58,468
% Change from 1990	5%	47%	9%	6%	8%	5%	-3%	60%	45%	60%	43%	15%	54%	22%
Feebates — Canada Only														
% imp. in FCR — $250/L/100 km	-3%	-3%	-3%	-3%										
New fuel efficiency	9.5	13.2	6.5	13.1										
New CO_2	**29,765**	**13,473**	**97**	**478**	869	117	114	7,251	1,398	805	3,433	44,913	12,887	57,801
% change from 2010 baseline	-1.5%	-1.5%	-1.5%	-1.5%	0%	0%	0%	0%	0%	0%	0%	-1%	0%	-1%
% Change from 1990	**4%**	**45%**	**8%**	**5%**	**8%**	**5%**	**-3%**	**60%**	**45%**	**60%**	**43%**	**13%**	**54%**	**20%**
% imp. in FCR — $500/L/100 km	-5%	-5%	-5%	-5%										
New fuel efficiency	9.4	13.0	6.4	13.0										
New CO_2	**29,463**	**13,336**	**96**	**473**	869	117	114	7,251	1,398	805	3,433	44,469	12,887	57,356
% change from 2010 baseline	-3%	-3%	-3%	-2%	0%	0%	0%	0%	0%	0%	0%	-2%	0%	-2%
% Change from 1990	**3%**	**43%**	**6%**	**4%**	**8%**	**5%**	**-3%**	**60%**	**45%**	**60%**	**43%**	**12%**	**54%**	**20%**
% imp. in FCR — $1,000/L/100 km	-10%	-10%	-10%	-10%										
New fuel efficiency	9.2	12.7	6.2	12.6										
New CO_2	**28,708**	**12,994**	**93**	**461**	869	117	114	7,251	1,398	805	3,433	43,357	12,887	56,244
% change from 2010 baseline	-5%	-5%	-5%	-5%	0%	0%	0%	0%	0%	0%	0%	-5%	0%	-4%
% Change from 1990	**0%**	**40%**	**4%**	**1%**	**8%**	**5%**	**-3%**	**60%**	**45%**	**60%**	**43%**	**10%**	**54%**	**17%**
% imp. in FCR — $2,000/litre/100 km	-18%	-18%	-18%	-18%										
New fuel efficiency	8.8	12.2	6.0	12.1										
New CO_2	**27,499**	**12,447**	**90**	**442**	869	117	114	7,251	1,398	805	3,433	41,577	12,887	54,465
% change from 2010 baseline	-9%	-9%	-9%	-9%	0%	0%	0%	0%	0%	0%	0%	-9%	0%	-7%
% Change from 1990	**-4%**	**34%**	**-1%**	**-3%**	**8%**	**5%**	**-3%**	**60%**	**45%**	**60%**	**43%**	**5%**	**54%**	**14%**

Examination of Individual Options, Feebates (North America-wide) *(for top 13 CMAs)*

	Automobiles and Light Trucks				Urban Transit			Road Freight				Total	Total	Total
	LDGA	LDGT	MC	LDDA	Bus	Rapid Transit	Pass. Rail	HDDV	HDGV	LDDT	LDGT	Passenger	Freight	
Baseline Data (1990)														
Vehicle stock (000s)	5,972	1,542	189	65	—	—	—	—	—	—	—			
Annual km per vehicle	17,600	16,500	2,800	17,600	—	—	—	—	—	—	—			
Fuel consumption ratio (L/100 km)	11.60	15.50	7.20	14.60	—	—	—	40.00	40.10	18.60	16.39			
CO_2 factor (g/L)	2,360	2,360	2,360	2,730	—	—	—	2,730	2,360	2,730	2,360			
CO_2 factor (g/veh-km) (transit: g/pass-km)	274	366	170	399	81	22	47	1,092	946	508	387			
Veh-km (billions)	105	25	0.5	1.1	0.57	0.18	0.01	4.1	1.0	1.0	6.2			
Pass-km/tonne-km	164	32	0.5	1.8	9.94	5.03	2.51	33.1	8.2	1.0	3.1			
CO_2 Emissions (kt)	**28,701**	**9,307**	**90**	**457**	**806**	**111**	**118**	**4,525**	**965**	**504**	**2,397**	39,589	8,390	47,979
Baseline Data (2010)														
Vehicle stock (000s)	7,122	2,552	208	72	—	—	—	—	—	—	—			
Annual km per vehicle	18,639	16,995	3,056	18,639	—	—	—	—	—	—	—			
Fuel consumption ratio (L/100 km)	9.65	13.4	6.6	13.3	—	—	—	36.4	37.5	17.4	13.4			
CO_2 factor (g/L)	2,360	2,360	2,360	2,730	—	—	—	2,730	2,360	2,730	2,360			
CO_2 factor (g/veh-km) (transit: g/pass-km)	228	315	155	363	73	20	36	995	884	475	315			
Veh-km (billions)	132.74	43	0.6	1.3	0.67	0.20	0.01	7.3	1.6	1.7	10.9			
Pass-km/tonne-km	207	55	1	2	11.9	5.8	3.2	58.3	12.6	1.7	5.4			
CO_2 Emissions (kt)	**30,218**	**13,678**	**98**	**486**	**869**	**117**	**114**	**7,251**	**1,398**	**805**	**3,433**	45,581	12,887	58,468
% Change from 1990	5%	47%	9%	6%	8%	5%	-3%	60%	45%	60%	43%	15%	54%	22%
Feebates — North America-wide														
% imp. in FCR — $250/L/100 km	-10%	-10%	-10%	-10%										
New fuel efficiency	9.2	12.7	6.2	12.6										
New CO_2	**28,708**	**12,994**	**93**	**461**	**869**	**117**	**114**	**7,251**	**1,398**	**805**	**3,433**	43,357	12,887	56,244
% change from 2010 baseline	-5%	-5%	-5%	-5%	0%	0%	0%	0%	0%	0%	0%	-5%	0%	-4%
% Change from 1990	**0%**	**40%**	**4%**	**1%**	**8%**	**5%**	**-3%**	**60%**	**45%**	**60%**	**43%**	10%	54%	17%
% mp. in FCR — $500/L/100 km	-14%	-14%	-14%	-14%										
New fuel efficiency	9.0	12.4	6.1	12.4										
New CO_2	**28,103**	**12,721**	**92**	**452**	**869**	**117**	**114**	**7,251**	**1,398**	**805**	**3,433**	42,467	12,887	55,354
% change from 2010 baseline	-7%	-7%	-7%	-7%	0%	0%	0%	0%	0%	0%	0%	-7%	0%	-5%
% Change from 1990	**-2%**	**37%**	**2%**	**-1%**	**8%**	**5%**	**-3%**	**60%**	**45%**	**60%**	**43%**	7%	54%	15%
% imp. in FCR — $1,000/L/100 km	-20%	-20%	-20%	-20%										
New fuel efficiency	8.7	12.0	5.9	12.0										
New CO_2	**27,197**	**12,310**	**89**	**437**	**869**	**117**	**114**	**7,251**	**1,398**	**805**	**3,433**	41,133	12,887	54,020
% change from 2010 baseline	-10%	-10%	-10%	-10%	0%	0%	0%	0%	0%	0%	0%	-10%	0%	-8%
% Change from 1990	**-5%**	**32%**	**-2%**	**-4%**	**8%**	**5%**	**-3%**	**60%**	**45%**	**60%**	**43%**	4%	54%	13%
% imp. in FCR — $2,000/L/100 km	-28%	-28%	-28%	-28%										
New fuel efficiency	8.3	11.5	5.6	11.4										
New CO_2	**25,988**	**11,763**	**85**	**418**	**869**	**117**	**114**	**7,251**	**1,398**	**805**	**3,433**	39,353	12,887	52,241
% change from 2010 baseline	-14%	-14%	-14%	-14%	0%	0%	0%	0%	0%	0%	0%	-14%	0%	-11%
% Change from 1990	**-9%**	**26%**	**-6%**	**-9%**	**8%**	**5%**	**-3%**	**60%**	**45%**	**60%**	**43%**	-1%	54%	9%

Exhibit [illegible] Examination of Individual Options, Inspection and Maintenance Programs *(for top 13 CMAs)*

	Automobiles and Light Trucks				Urban Transit			Road Freight				Total	Total	Total
	LDGA	LDGT	MC	LDDA	Bus	Rapid Transit	Pass. Rail	HDDV	HDGV	LDDT	LDGT	Passenger	Freight	
Baseline Data (1990)														
Vehicle stock (000s)	5,972	1,542	189	65	—	—	—	—	—	—	—			
Annual km per vehicle	17,600	16,500	2,800	17,600	—	—	—	—	—	—	—			
Fuel consumption ratio (L/100 km)	11.60	15.50	7.20	14.60	—	—	—	40.00	40.10	18.60	16.39			
CO_2 factor (g/L)	2,360	2,360	2,360	2,730	—	—	-	2,730	2,360	2,730	2,360			
CO_2 factor (g/veh-km) (transit: g/pass-km)	274	366	170	399	81	22	47	1,092	946	508	387			
Veh-km (billions)	105	25	0.5	1.1	0.57	0.18	0.01	4.1	1.0	1.0	6.2			
Pass-km/tonne-km	164	32	0.5	1.8	9.94	5.03	2.51	33.1	8.2	1.0	3.1			
CO_2 Emissions (kt)	**28,701**	**9,307**	**90**	**457**	**806**	**111**	**118**	**4,525**	**965**	**504**	**2,397**	**39,589**	**8,390**	**47,979**
Baseline Data (2010)														
Vehicle stock (000s)	7,122	2,552	208	72	—	—	—	—	—	—	—			
Annual km per vehicle	18,639	16,995	3,056	18,639	—	—	—	—	—	—	—			
Fuel consumption ratio (L/100 km)	9.65	13.4	6.6	13.3	—	—	—	36.4	37.5	17.4	13.4			
CO_2 factor (g/L)	2,360	2,360	2,360	2,730	—	—	—	2,730	2,360	2,730	2,360			
CO_2 factor (g/veh-km) (transit: g/pass-km)	228	315	155	363	73	20	36	995	884	475	315			
Veh-km (billions)	132.74	43	0.6	1.3	0.67	0.20	0.01	7.3	1.6	1.7	10.9			
Pass-km/tonne-km	207	55	1	2	11.9	5.8	3.2	58.3	12.6	1.7	5.4			
CO_2 Emissions (kt)	**30,218**	**13,678**	**98**	**486**	**869**	**117**	**114**	**7,251**	**1,398**	**805**	**3,433**	**45,581**	**12,887**	**58,468**
% Change from 1990	**5%**	**47%**	**9%**	**6%**	**8%**	**5%**	**-3%**	**60%**	**45%**	**60%**	**43%**	**15%**	**54%**	**22%**
Inspection and Maintenance Programs														
% reduction in CO_2 from baseline	-1%	-1%	-1%	-1%	1%	-1%	-1%	-1%	-1%	-1%	-1%			
New CO_2	**29,916**	**13,541**	**97**	**481**	**860**	**115**	**113**	**7,179**	**1,384**	**797**	**3,399**	**45,125**	**12,758**	**57,883**
% change from 2010 baseline	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%
% change from 1990	4%	45%	8%	5%	7%	4%	-4%	59%	43%	58%	42%	14%	52%	21%
% reduction in CO_2 from baseline	-3%	-3%	-3%	-3%	-3%	-3%	-3%	-3%	-3%	-3%	-3%			
New CO_2	**29,312**	**13,268**	**95**	**471**	**843**	**113**	**111**	**7,034**	**1,356**	**781**	**3,330**	**44,213**	**12,501**	**56,714**
% change from 2010 baseline	-3%	-3%	-3%	-3%	-3%	-3%	-3%	-3%	-3%	-3%	-3%	-3%	-3%	-3%
% Change from 1990	**2%**	**43%**	**6%**	**3%**	**5%**	**2%**	**-6%**	**55%**	**41%**	**55%**	**39%**	**12%**	**49%**	**18%**

Examination of Individual Options, Parking Pricing and Supply *(for top 13 CMAs)*

	Automobiles and Light Trucks				Urban Transit			Road Freight				Total	Total	Total
	LDGA	LDGT	MC	LDDA	Bus	Rapid Transit	Pass. Rail	HDDV	HDGV	LDDT	LDGT	Passenger	Freight	
Baseline Data (1990)														
Vehicle stock (000s)	5,972	1,542	189	65	—	—	—	—	—	—	—			
Annual km per vehicle	17,600	16,500	2,800	17,600	—	—	—	—	—	—	—			
Fuel consumption ratio (L/100 km)	11.60	15.50	7.20	14.60	—	—	—	40.00	40.10	18.60	16.39			
CO_2 factor (g/L)	2,360	2,360	2,360	2,730	—	—	—	2,730	2,360	2,730	2,360			
CO_2 factor (g/veh-km) (transit: g/pass-km)	274	366	170	399	81	22	47	1,092	946	508	387			
Veh-km (billions)	105	25	0.5	1.1	0.57	0.18	0.01	4.1	1.0	1.0	6.2			
Pass-km/tonne-km	164	32	0.5	1.8	9.94	5.03	2.51	33.1	8.2	1.0	3.1			
CO_2 Emissions (kt)	**28,701**	**9,307**	**90**	**457**	**806**	**111**	**118**	**4,525**	**965**	**504**	**2,397**	**39,589**	**8,390**	**47,979**
Baseline Data (2010)														
Vehicle stock (000s)	7,122	2,552	208	72	—	—	—	—	—	—	—			
Annual km per vehicle	18,639	16,995	3,056	18,639	—	—	—	—	—	—	—			
Fuel consumption ratio (L/100 km)	9.65	13.4	6.6	13.3	—	—	—	36.4	37.5	17.4	13.4			
CO_2 factor (g/L)	2,360	2,360	2,360	2,730	—	—	—	2,730	2,360	2,730	2,360			
CO_2 factor (g/veh-km) (transit: g/pass-km)	228	315	155	363	73	20	36	995	884	475	315			
Veh-km (billions)	132.74	43	0.6	1.3	0.67	0.20	0.01	7.3	1.6	1.7	10.9			
Pass-km/tonne-km	207	55	1	2	11.9	5.8	3.2	58.3	12.6	1.7	5.4			
CO_2 Emissions (kt)	**30,218**	**13,678**	**98**	**486**	**869**	**117**	**114**	**7,251**	**1,398**	**805**	**3,433**	45,581	12,887	58,468
% Change from 1990	5%	47%	9%	6%	8%	5%	-3%	60%	45%	60%	43%	15%	54%	22%
Parking Pricing (5% annual increase from 2000-2010)														
Annual increase in parking price ($/yr 2000-2010)	5%	5%	5%	5%										
Total increase (%)	163%	163%	163%	163%										
Elasticity for urban areas (price vs. veh-km)	-0.15	-0.15	-0.15	-0.15										
Elasticity for trips to downtowns (price vs. veh-km)	-1.00	-1.00	-1.00	-1.00										
Baseline urban veh-km (excluding downtowns)	128.5	42.3	0.6	1.3										
Baseline veh-km for trips to top 3 downtowns	4.2	1.0	0.0	0.0										
New urban veh-km	116.4	38.3	0.6	1.2										
New downtown veh-km	1.6	0.4	0.0	0.0										
New veh-km	118.0	38.7	0.6	1.2										
Pass-km shifted to transit (25% of reductions)	4.3	1.2	0.0	0.0										
New pass-km	202.8	53.5	0.6	2.0	15.02	7.36	4.01							
New CO_2	26,855	12,213	87	431	1,097	147	144	7,251	1,398	805	3,433	40,974	12,887	53,862
% change from 2010 baseline	-11%	-11%	-11%	-11%	26%	26%	26%	0%	0%	0%	0%	-10%	0%	-8%
% Change from 1990	**-6%**	**31%**	**-3%**	**-6%**	**36%**	**33%**	**22%**	**60%**	**45%**	**60%**	**43%**	3%	54%	12%
Parking Supply Scenario (5% annual decrease from 2000-2010)														
Annual increase in parking price ($/yr 2000-2010)	5%	5%	5%	5%										
Total increase (%)	163%	163%	163%	163%										
Elasticity for urban areas (price vs. veh-km)	-0.15	-0.15	-0.15	-0.15										
Elasticity for trips to downtowns (price vs. veh-km)	-1.00	-1.00	-1.00	-1.00										
Baseline urban veh-km (excluding downtowns)	128.5	42.3	0.6	1.3										
Baseline veh-km for trips to top 3 downtowns	4.2	1.0	0.0	0.0										
New urban veh-km	116.4	38.3	0.6	1.2										
New downtown veh-km	1.6	0.4	0.0	0.0										
New veh-km	118.0	38.7	0.6	1.2										
Pass-km shifted to transit (25% of reductions)	4.3	1.2	0.0	0.0										
New pass-km					15.02	7.36	4.01							
New CO_2	26,855	12,213	87	431	1,097	147	144	7,251	1,398	805	3,433	40,974	12,887	53,862
% change from 2010 baseline	-11%	-11%	-11%	-11%	26%	26%	26%	0%	0%	0%	0%	-10%	0%	-8%
% Change from 1990	**-6%**	**31%**	**-3%**	**-6%**	**36%**	**33%**	**22%**	**60%**	**45%**	**60%**	**43%**	3%	54%	12%

Exhibit II.9 *Examination of Individual Options, Congestion Pricing ($0.10/km peak and $0.05/km off-peak)*
(for top 13 CMAs)

	Automobiles and Light Trucks				Urban Transit			Road Freight				Total	Total	Total
	LDGA	LDGT	MC	LDDA	Bus	Rapid Transit	Pass. Rail	HDDV	HDGV	LDDT	LDGT	Passenger	Freight	
Baseline Data (1990)														
Vehicle stock (000s)	5,972	1,542	189	65	—	—	—	—	—	—	—			
Annual km per vehicle	17,600	16,500	2,800	17,600	—	—	—	—	—	—	—			
Fuel consumption ratio (L/100 km)	11.60	15.50	7.20	14.60	—	—	—	40.00	40.10	18.60	16.39			
CO_2 factor (g/L)	2,360	2,360	2,360	2,730	—	—	—	2,730	2,360	2,730	2,360			
CO_2 factor (g/veh-km) (transit: g/pass-km)	274	366	170	399	81	22	47	1,092	946	508	387			
Veh-km (billions)	105	25	0.5	1.1	0.57	0.18	0.01	4.1	1.0	1.0	6.2			
Pass-km/tonne-km	164	32	0.5	1.8	9.94	5.03	2.51	33.1	8.2	1.0	3.1			
CO_2 Emissions (kt)	**28,701**	**9,307**	**90**	**457**	**806**	**111**	**118**	**4,525**	**965**	**504**	**2,397**	39,589	8,390	47,979
Baseline Data (2010)														
Vehicle stock (000s)	7,122	2,552	208	72	—	—	—	—	—	—	—			
Annual km per vehicle	18,639	16,995	3,056	18,639	—	—	—	—	—	—	—			
Fuel consumption ratio (L/100 km)	9.65	13.4	6.6	13.3	—	—	—	36.4	37.5	17.4	13.4			
CO_2 factor (g/L)	2,360	2,360	2,360	2,730	—	—	—	2,730	2,360	2,730	2,360			
CO_2 factor (g/veh-km) (transit: g/pass-km)	228	315	155	363	73	20	36	995	884	475	315			
Veh-km (billions)	132.74	43	0.6	1.3	0.67	0.20	0.01	7.3	1.6	1.7	10.9			
Pass-km/tonne-km	207	55	1	2	11.9	5.8	3.2	58.3	12.6	1.7	5.4			
CO_2 Emissions (kt)	**30,218**	**13,678**	**98**	**486**	**869**	**117**	**114**	**7,251**	**1,398**	**805**	**3,433**	45,581	12,887	58,468
% Change from 1990	5%	47%	9%	6%	8%	5%	-3%	60%	45%	60%	43%	15%	54%	22%
Congestion Pricing ($0.10/km peak and $0.05/km off peak on limited access highways)														
Peak														
Base auto cost/km (from Hwy 407 Study)	$0.10	$0.10	$0.10	$0.10				$0.40	$0.40	$0.40	$0.40			
Increase in cost ($/km)	$0.10	$0.10	$0.10	$0.10				$0.20	$0.20	$0.20	$0.20			
Elasticity (price vs. veh-km)	-0.20	-0.20	-0.20	-0.20				-0.20	-0.20	-0.20	-0.20			
Veh-km on limited-access highways (peak)	13.3	4.3	0.1	0.1				0.7	0.2	0.2	1.1			
New veh-km on limited-access highways	10.6	3.5	0.1	0.1				0.7	0.1	0.2	1.0			
CO_2 reduction (kt)	604.4	273.6	2.0	9.7				72.5	14.0	8.1	34.3			
Off-Peak														
Base auto cost/km (from Hwy 407 Study)	$0.10	$0.10	$0.10	$0.10				$0.40	$0.40	$0.40	$0.40			
Increase in cost ($/km)	$0.05	$0.05	$0.05	$0.05				$0.10	$0.10	$0.10	$0.10			
Elasticity (price vs. veh-km)	-0.20	-0.20	-0.20	-0.20				-0.20	-0.20	-0.20	-0.20			
Veh-km on limited-access highways (off-peak)	13.3	4.3	0.1	0.1				0.7	0.2	0.2	1.1			
New veh-km on limited-access highways	11.9	3.9	0.1	0.1				0.7	0.2	0.2	1.0			
CO_2 reduction (kt)	302.2	136.8	1.0	4.9				36.3	7.0	4.0	17.2			
Pass-km shifted to transit (25% of reductions)	1.0	0.3	0.0	0.0										
New pass-km					12.67	6.21	3.38							
New CO_2	29,312	13,268	95	471	925	124	122	7,142	1,377	793	3,382	44,317	12,694	57,010
% change from 2010 baseline	-3%	-3%	-3%	-3%	6%	6%	6%	-2%	-2%	-2%	-2%	-3%	-1%	-2%
% Change from 1990	2%	43%	6%	3%	15%	12%	3%	58%	43%	57%	41%	12%	51%	19%

Exhibit 6.10 *Examination of Individual Options, Congestion Pricing ($0.20/km peak and $0.10/km off-peak)* *(for top 13 CMAs)*

	Automobiles and Light Trucks				Urban Transit			Road Freight				Total	Total	Total
	LDGA	LDGT	MC	LDDA	Bus	Rapid Transit	Pass. Rail	HDDV	HDGV	LDDT	LDGT	Passenger	Freight	
Baseline Data (1990)														
Vehicle stock (000s)	5,972	1,542	189	65	—	—	—	—	—	—	—			
Annual km per vehicle	17,600	16,500	2,800	17,600	—	—	—	—	—	—	—			
Fuel consumption ratio (L/100 km)	11.60	15.50	7.20	14.60	—	—	—	40.00	40.10	18.60	16.39			
CO_2 factor (g/L)	2,360	2,360	2,360	2,730	—	—	—	2,730	2,360	2,730	2,360			
CO_2 factor (g/veh-km) (transit: g/pass-km)	274	366	170	399	81	22	47	1,092	946	508	387			
Veh-km (billions)	105	25	0.5	1.1	0.57	0.18	0.01	4.1	1.0	1.0	6.2			
Pass-km/tonne-km	164	32	0.5	1.8	9.94	5.03	2.51	33.1	8.2	1.0	3.1			
CO_2 Emissions (kt)	**28,701**	**9,307**	**90**	**457**	**806**	**111**	**118**	**4,525**	**965**	**504**	**2,397**	**39,589**	**8,390**	**47,979**
Baseline Data (2010)														
Vehicle stock (000s)	7,122	2,552	208	72	—	—	—	—	—	—	—			
Annual km per vehicle	18,639	16,995	3,056	18,639	—	—	—	—	—	—	—			
Fuel consumption ratio (L/100 km)	9.65	13.4	6.6	13.3	—	—	—	36.4	37.5	17.4	13.4			
CO_2 factor (g/L)	2,360	2,360	2,360	2,730	—	—	—	2,730	2,360	2,730	2,360			
CO_2 factor (g/veh-km) (transit: g/pass-km)	228	315	155	363	73	20	36	995	884	475	315			
Veh-km (billions)	132.74	43	0.6	1.3	0.67	0.20	0.01	7.3	1.6	1.7	10.9			
Pass-km/tonne-km	207	55	1	2	11.9	5.8	3.2	58.3	12.6	1.7	5.4			
CO_2 Emissions (kt)	**30,218**	**13,678**	**98**	**486**	**869**	**117**	**114**	**7,251**	**1,398**	**805**	**3,433**	**45,581**	**12,887**	**58,468**
% Change from 1990	**5%**	**47%**	**9%**	**6%**	**8%**	**5%**	**-3%**	**60%**	**45%**	**60%**	**43%**	**15%**	**54%**	**22%**
Congestion Pricing ($0.20/km peak and $0.10/km off-peak on limited-access highways)														
Peak														
Base auto cost/km (from Hwy 407 Study)	$0.10	$0.10	$0.10	$0.10				$0.40	$0.40	$0.40	$0.40			
% increase in cost	$0.20	$0.20	$0.20	$0.20				$0.40	$0.40	$0.40	$0.40			
Elasticity (price vs. veh-km)	-0.20	-0.20	-0.20	-0.20				-0.20	-0.20	-0.20	-0.20			
Baseline veh-km (all urban)	132.74	43.37	0.64	1.34				7.29	1.58	1.70	10.89			
Veh-km on limited-access highways (peak)	13.3	4.3	0.1	0.1				0.7	0.2	0.2	1.1			
New veh-km on limited-access highways	8.0	2.6	0.0	0.1				0.6	0.1	0.1	0.9			
CO_2 reduction (kt)	1,208.7	547.1	3.9	19.4				145.0	28.0	16.1	68.7			
Off-Peak														
Base auto cost/km (from Hwy 407 Study)	$0.10	$0.10	$0.10	$0.10				$0.40	$0.40	$0.40	$0.40			
% increase in cost	$0.10	$0.10	$0.10	$0.10				$0.20	$0.20	$0.20	$0.20			
Elasticity (price vs. veh-km)	-0.20	-0.20	-0.20	-0.20				-0.20	-0.20	-0.20	-0.20			
Baseline veh-km (all urban)	132.74	43.37	0.64	1.34				7.29	1.58	1.70	10.89			
Veh-km on limited-access highways (off-peak)	13.3	4.3	0.1	0.1				0.7	0.2	0.2	1.1			
New veh-km on limited-access highways	10.6	3.5	0.1	0.1				0.7	0.1	0.2	1.0			
CO_2 reduction (kt)	604.4	273.6	2.0	9.7				72.5	14.0	8.1	34.3			
Pass-km shifted to transit (25% of reductions)	2.0	0.7	0.0	0.0										
New pass-km					13.43	6.58	3.59							
New CO_2	28,405	12,857	92	456	980	132	129	7,034	1,356	781	3,330	43,052	12,501	55,553
% change from 2010 baseline	-6%	-6%	-6%	-6%	13%	13%	13%	-3%	-3%	-3%	-3%	-6%	-3%	-5%
% Change from 1990	**-1%**	**38%**	**3%**	**0%**	**22%**	**19%**	**9%**	**55%**	**41%**	**55%**	**39%**	**9%**	**49%**	**16%**

Appendix C

Estimating the Impacts of Integrated Options to Reduce CO_2

Integrated Package A

Description of Package A

Two variations of the integrated Package A were examined: one assumed that the measures would be implemented in Canada only and the other assumed that the measures would be implemented North America-wide. The integrated Package A was constructed around the following measures:

- a gasoline tax increase of 3 cents/litre/year starting in 2000;
- a diesel fuel tax increase of 3 cents/litre/year starting in 2000 (North America-wide package);
- Corporate Average Fuel Efficiency/Consumption (CAFE/CAFC) standards introduced in 2005; and
- a feebate program introduced in 2005 (assumes a rate of C$1,400/litre/100 kilometre [km]).

Package A Methodology

In order to estimate CO_2 reductions for Package A, each measure (and associated impact) was examined in terms of how its impacts would change if implemented in combination with the other measures. The conclusions about each option are summarized below:

- The impact of fuel taxes on demand may be reduced slightly if CAFE standards and feebate standards result in better fuel economy and lower fuel costs for individuals. Because CAFE standards and feebates will have resulted in fairly modest improvements in fuel efficiency by 2010 (if implemented in 2005), their moderating effect on fuel taxes is likely to be small.
- In the analysis presented in Appendix B, the impacts of CAFC and CAFE on CO_2 emissions were estimated to be -1.4% and -2.5% respectively for passenger transport modes (e.g., cars and light trucks). In estimating these impacts, it was assumed that there would be a 30% take-back effect due to the reduced fuel costs to the individual. Fuel pricing measures would reduce this take-back effect.
- The impacts of feebates (C$1,400/litre/100 km) were estimated to be -10% for the North America-wide scenario and -5% for the Canada-only scenario. The impacts of feebates may be enhanced by fuel taxes, since vehicle purchasers may

be more interested in vehicle fuel efficiency. On the other hand, manufacturers may have less incentive to produce more fuel efficient vehicles if both CAFE and feebate measures are employed. In order to be effective under the integrated options, the CAFE/CAFC standards and feebate rates would need to be adjusted accordingly to produce the desired effects.

It is difficult to estimate the combined impacts of fuel taxes, CAFE/CAFC and feebates because of the complex interactions among these various measures. As determined through the evaluation of the individual measures (described in Appendix B), the net impact of a 3 cents/litre/year gasoline tax increase, assuming an elasticity of -0.15 with respect to fuel efficiency, was about a 4% reduction in CO_2. This estimate takes into account the fact that the gasoline tax increase is gradual, and that it takes considerable time for the vehicle stock to be replaced. By comparison, the net impact on fuel efficiency (and therefore CO_2) of CAFE standards and feebates (C$1,400/litre/year) was estimated to be -1.2% and -5% respectively for the Canada-only scenario.

Due to the relatively small impacts of each of these measures, it is sufficient for this analysis to assume that the impacts of each measure on vehicle fuel efficiency would be additive. In other words, the combined impact of the Canada-only measures would be a 10% improvement in gasoline fuel efficiency. Although it could be argued that there is some overlap between CAFE standards (which affect the vehicles produced by manufacturers) and feebates (which affect the consumer's choice of vehicles), it has been assumed that the feebate rates and CAFE standards would be adjusted accordingly to provide the desired results. One possible impact of the combined measures would be a much accelerated rate of vehicle replacement, which in turn would increase the rate of fuel efficiency improvement of the total vehicle stock.

Package A Results

Exhibit C.1 provides a detailed summary of the impacts of the integrated Package A by mode. Based on the assumptions outlined above, the net impact of the three measures if implemented on a Canada-only basis would be a 16% reduction for passenger vehicles and a 5% reduction for freight vehicles (gasoline only). In the Canada-only case, it was assumed that diesel fuel taxes would not be increased for reasons of international competitiveness. If implemented on a North America-wide basis, the effects would be a reduction of 26% from the 2010 baseline CO_2 emissions predicted for passenger transportation and a 14% reduction from the baseline for freight vehicles. In terms of meeting the Kyoto targets, the North America-wide scenario would exceed a 6% reduction from 1990 levels by 2010 for passenger vehicles, as well as overall. If implemented on a Canada-only basis, the impacts of fuel prices, CAFC and feebates on vehicle technology and CO_2 emissions are much reduced. With the level of fuel price increases assumed, the Kyoto target would not be met for the Canada-only scenario.

Exhibit C.1

Impacts of Integrated Package A

	Annual CO_2 (Kilotonnes)			Change from 2010 Baseline			Change from 1990		
	Passenger	Freight	Total	Passenger	Freight	Total	Passenger	Freight	Total
1990	39,589	8,390	47,979	—	—	—			
2010 baseline	45,581	12,887	58,468	—	—	—	15%	54%	22%
2010 New Scenarios									
Canada only	38,143	12,287	50,430	-16%	-5%	-14%	-4%	46%	5%
North America-wide	33,526	11,043	44,569	-26%	-14%	-24%	-15%	32%	-7%

Integrated Package B

Description of Package B

The integrated Package B was constructed around the following measures:

- vehicle inspection and maintenance with full implementation by 2000;
- vehicle charges (annual registration fees), with a technology impact equivalent to feebates;
- vehicle taxes (distance-based fees), with a demand impact similar to fuel taxes;
- parking pricing (5% annual increase from 2000 to 2010);
- road pricing ($0.10 peak/$0.05 off-peak on major expressways); and
- alternative fuels (not quantified).

Of the above measures, the first two generally affect vehicle technology, although the impact of vehicle charges and taxes could also influence demand depending on whether they are distance-based schemes. The remaining measures, with the exception of alternative fuels, are primarily demand-related measures.

Package B Methodology

As with Package A, there is a complex relationship between the above measures. A discussion of what each measure affects (e.g., technology or demand) and how these impacts would change under an integrated scenario is provided below:

- **Parking pricing/supply:** Parking pricing and supply management is a very specific measure directed primarily at peak period commuter trips. Although there would be some overlap between parking pricing, vehicle charges and road pricing, it is reasonable to assume that the majority of the reductions estimated for the individual options would take place under the integrated option.

- **Road pricing:** Road pricing is applied to all urban expressways, thereby affecting a wide variety of trips. There is some overlap between road pricing and parking pricing (e.g., for someone making a trip between a suburb and a downtown area). The impact of road pricing implemented in combination with other pricing increases will depend on the total increased cost to the individual. Depending on the type of trip, it may be that neither road pricing nor parking pricing alone would affect the travel behaviour of some people, but in combination they would.

- **Vehicle charges:** Because of the wide variety of forms that vehicle charges could take (e.g., pay-at-the-pump, distance-based registration fees, etc.), this study simply assumed to that vehicle charges would be implemented to cause reductions similar to those of fuel taxes. The same reductions were also assumed under the integrated options.

- **Vehicle taxes:** Vehicle taxes would be assessed on the purchase of vehicles and were assumed to have an impact similar to feebates. The percentage reduction in CO_2 produced by vehicle charges under the individual option was also assumed for the integrated options.

- **Vehicle inspection and maintenance (I&M):** As discussed in the main body of the report, vehicle I&M is estimated to reduce overall CO_2 emissions by 1% to 3% with respect to the 2010 business-as-usual baseline. This percentage reduction would not be affected by the various demand measures. However, because the other measures in the package would have reduced the overall amount of CO_2, the absolute reduction would be lower. The improvements in fuel efficiency resulting from CAFE and feebates may partly negate the impacts of vehicle I&M. However, these impacts would be difficult to quantify without the use of a sophisticated model and are therefore not included in calculating the CO_2 reduction impact of Package B.

A fairly straightforward approach was used to estimate the combined impacts of the measures in Package B. For the demand-related measures (e.g., parking pricing, road pricing and vehicle charges), the individual impacts were simply added together. Similarly, the percentage reductions in fuel consumption, and hence CO_2, produced by the individual technology measures were applied to the reduced estimate of CO_2 resulting from the demand measures.

Package B Results

Exhibit C.2 summarizes the results of Package B, showing the estimated impacts if implemented with and without harmonization with the United States. The primary difference between these scenarios is that vehicle charges and taxes, if implemented North America-wide, would have a more profound impact on auto manufacturers and vehicle technologies. Under the harmonization scenario with the United States, the CO_2 reductions would be very significant. For passenger transportation modes, CO_2 emissions would be reduced by 30% from the baseline 2010 emissions. For freight

transportation, emissions would be reduced by 15%. Overall, compared with the 1990 baseline emissions, the net impact of the measures would be in the order of an 11% reduction. Under the Canada-only scenario, the combined impact of the measures would be reduced somewhat, but the net result would still be significant. In fact, under the Canada-only scenario, Package B would fall just short of the Kyoto target when passenger and freight transportation are combined.

Exhibit C-2

Impacts of Integrated Package B

	Annual CO_2 (Kilotonnes)			Change from 2010 Baseline			Change from 1990		
	Passenger	Freight	Total	Passenger	Freight	Total	Passenger	Freight	Total
1990	39,589	8,390	47,979	—	—	—			
2010 baseline	45,581	12,887	58,468	—	—	—	15%	54%	22%
2010 New Scenarios									
Canada only	33,716	11,930	45,645	-26%	-7%	-22%	-15%	42%	-5%
North America-wide	31,962	10,977	42,940	-30%	-15%	-27%	-19%	31%	-11%

Integrated Package C

Description of Package C

The integrated Package C was constructed around the following measures:

- a gasoline tax increase of 3 cents/litre/year starting in 2000;
- a diesel fuel tax increase of 3 cents/litre/year starting in 2000 (North America-wide package);
- CAFE or CAFC standards introduced in 2005;
- a feebate program introduced in 2005 (assuming a rate of C$1,400/litre/100 km);
- vehicle inspection and maintenance with full implementation by 2000;
- parking pricing (5% annual increase from 2000 to 2010);
- road pricing ($0.10 peak/$0.05 off-peak on major expressways);
- transportation demand management initiatives;
- enhanced transit; and
- land use/urban design.

Package C Methodology

The general approach for estimating the impacts of the Comprehensive Package was to assume that the regulatory measures would have the same impact when applied together as they would when applied individually. This assumption is based on the premise that the impact of the individual options would be enhanced if implemented in a comprehensive package, thereby balancing out the overlap between some of the measures. The impacts of the measures to expand modal choice were taken into account by increasing the elasticity of demand to fuel price — it was assumed that the options to expand modal choice would enhance the impacts of fuel taxes by providing alternatives to auto transportation. By increasing the elasticity of demand to fuel price from -0.15 to -0.2, the net impact is an approximate reduction in demand of 3.5% for the Canada-only scenario. This is a fairly moderate percentage reduction. However, it should be recognized that the majority of options for expanding modal choice (e.g., land use and enhanced transit) will take a long time to take effect.

Package C Results

Exhibit C.3 summarizes the results of a comprehensive package of measures. Assuming the package is implemented in Canada alone, CO_2 emissions from passenger transportation may be reduced by over 30% from the baseline 2010 levels and by about 22% from 1990 levels. Taking both passenger and freight transportation into account, the net impact of the Comprehensive Package was estimated to be an 11% reduction from 1990 levels, which exceeds the Kyoto target of 6%. It should be recognized that this is an illustrative scenario only. Different price increases or regulatory controls would result in different reductions.

For the North America-wide scenario, the Comprehensive Package would meet the Kyoto target reductions, achieving a 20% reduction from 1990 levels when both passenger and freight modes are combined. As with the Canada-only scenario, freight transportation would not meet the targets on its own.

Exhibit C.3

Impacts of Integrated Package C

	Annual CO_2 (Kilotonnes)			Change from 2010 Baseline			Change from 1990		
	Passenger	Freight	Total	Passenger	Freight	Total	Passenger	Freight	Total
1990	39,589	8,390	47,979	—	—	—			
2010 baseline	45,581	12,887	58,468	—	—	—	15%	54%	22%
2010 New Scenarios									
Canada only	31,060	11,604	42,663	-32%	-10%	-27%	-22%	38%	-11%
North America-wide	27,968	10,417	38,385	-39%	-19%	-34%	-29%	24%	-20%

Greenhouse Gas Emissions from Urban Transportation

National Round Table on the Environment and the Economy

Table ronde nationale sur l'environnement et l'économie

Canada Building, 344 Slater Street, Suite 200, Ottawa, Ontario, Canada K1R 7Y3
Tel.: (613) 992-7189 • Fax: (613) 992-7385 • E-mail: admin@nrtee-trnee.ca • Web: http://www.nrtee-trnee.ca

Printed in Canada on recycled paper